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THE CELLULAR TRANSMISSION OF SUBSTANCES, ESPECIALLY NEUROHUMORS

THE ANNUAL SOMERVILLE LECTURE DELIVERED AT McGILL UNIVERSITY NOVEMBER 24, 1933

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Harvard University

IN ACCEPTING the invitation of the Dean and the Faculty of Graduate Studies and Research at McGill University to deliver the Annual Somerville Lecture I wish at the outset to express my keen appreciation of the honor done me and to extend my sincere thanks to the Dean and the Faculty for this opportunity to address you. It is furthermore a great pleasure for me to occupy a lectureship, the present position of which is in large measure due to the efforts of my former associate at the Woods Hole Marine Laboratory, Dr. Arthur Willey, whose leadership in the early days of seaside work meant so much to us all. The seashore is indeed the place of all places where the study of animal life can best be carried on and much of what I shall have to say to you this evening represents work done at the Woods Hole station where Dr. Willey, Dr. Lloyd, and many others from your laboratories have worked.

COLOR CHANGES IN ANIMALS

I have selected for my address the topic neurohumoral transmission, a subject which is an outgrowth of the general field of animal coloration. I am emboldened to think that this subject might well have interested the founder of this lectureship, Mr. James Somerville, for it is a part of the natural history of animals, a field in which as an educator he was notably active. Animal coloration has had a long history, for it has claimed the attention of investigators from the days of Aristotle and of Pliny. You are doubtless aware that many animals can alter their tints with remarkable rapidity and that in such forms as the African chameleon this ability has come to be truly proverbial. Some creatures, such as the devil fishes and squids, accomplish this transformation by many small systems of radiating muscle fibers whereby minute sacs of colored materials may be expanded or contracted, thus producing that unusual play of colors which characterizes these animals. Other forms, such as the shrimps, prawns, fishes, frogs, toads, and lizards, possess a much simpler device in which individual pigment cells or chromatophores concentrate or disperse their

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contained pigment and thus withdraw or spread to view their colors. The resulting changes in the tints of these animals may be said to be due in part to the external and in part to the internal environment. It is in particular to this type of chromatophore that I wish to direct your attention, for the methods involved in its action call for the application of rather novel and remarkable principles that are of no small importance, in my opinion, in the elucidation of many organic relations. In treating this subject I shall limit myself in the main to the conditions of the chromatophores in the vertebrates and particularly in the fishes, but I shall show you, I hope, that the principles thus brought forward apply very broadly and are probably of considerable significance not only for many vital processes in animals but in plants also.

Among the ancients both Seneca and Pliny record the color changes of certain fishes as, for instance, the mullet whose activity in this respect played an important part in the preparations for Roman feasts. Records of this kind occur through later times. In 1819 Sangiovanni first saw clearly the chromatophores of cephalopods. He introduced the word chromatophore, in Italian *cromoforo*, portrayed the movements of these cells, and expressed the belief that they were under the influence of nerves. The chromatophores of lizards were first clearly described by Milne-Edwards in 1834, of frogs by Ascherson in 1840, and of fishes by von Siebold and by Buchholz independently in 1863. Meanwhile in 1830 the adaptive relations of the color changes in fishes to the backgrounds on which they rested had been pointed out by Stark.

In a series of papers published by Pouchet between 1871 and 1878 this distinguished French investigator demonstrated, especially in the flatfishes, the control of chromatophores by nerves and in particular by the sympathetic nerves (Fig. 1). The actual innervation of chromatophores in fishes was subsequently figured by Ballowitz (1893) who studied this subject by appropriate histological methods (Fig. 2). In 1852 Brücke had presented evidence in favor of nervous influence over the chromatophores in the chameleon. As a result of these and other studies the belief in the nervous control of chromatophores became generally accepted. But the best efforts of many investigators including such workers as Vulpian (1875), Bimmermann (1878), and Biedermann (1892) yielded no conclusive evidence in favor of this opinion as applied to the amphibian chromatophores. Following on Corona and Moroni's discovery in 1898 that the pigment in frog chromatophores is concentrated by adrenalin and Smith's discovery that the removal of the pituitary gland from the tadpole results likewise in a concentration of the pigment in its chromatophores, came a series of papers centering chiefly about the work of Hogben, one of your former associates. In these papers it was shown that the amphibian pigment cells were controlled almost exclusively by pituitary secretions and not by nerves (Figs. 3 and 4). This conclusion was in strong contrast with what had been established for the fishes and with what seemed true for the lizards, for though Redfield had shown in 1916 that a hormone, probably adrenalin, was one of the agents in the concentration of pigment in the chromatophores of *Phrynosoma*, most workers including Redfield himself admitted that nerves were the chief controlling factors for color changes in these animals (Fig. 5). Thus at the beginning of the present decade the majority of investigators in this field would have agreed that the control of vertebrate chromatophores

was by nerves in fishes, by hormones in amphibians, and in the main by nerves in lizards.

These somewhat anomalous conclusions led me to speculate on a possible unification in this field of work. In a lecture delivered at the University of Cambridge, England, in May, 1930, and subsequently published as a small volume entitled *Humoral Agents in Nervous Activity*, I suggested that where nerves appeared to control chromatophores they might do so by secreting from their terminals material which, like adrenalin or pituitrin, would bring about a concentration or a dispersion of pigment in these cells. Hence the so-called nervous control and the humoral control of chromatophores might be regarded as essentially the same. In what is assumed to be the nervous control of chromatophores the active substance is produced, according to this interpretation, in very close proximity to the reacting cell; in the humoral control this substance is produced at a distance and is then carried by blood and lymph to the chromatophore. The substances thus involved I have called neurohumors to use a term introduced by Henri Fredericq in 1927, and the idea that chromatophores as well as other effectors, and even neurones themselves, could be thus excited to activity I designated as neurohumoralism. After having worked out this unification I was interested to find that essentially the same idea as that just detailed had been advanced by Professor Giersberg in 1930 and published by him in a paper on the general color changes in animals. It is gratifying to find that the specula-

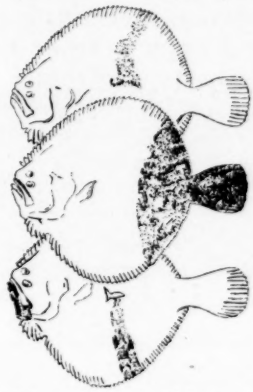

FIG. 1. TURBOTS IN WHICH THE MELANOPHORES HAVE BEEN RENDERED DARK AND INOPERATIVE BY THE CUTTING OF THE CONTROLLING NERVES
Pouchet, 1876

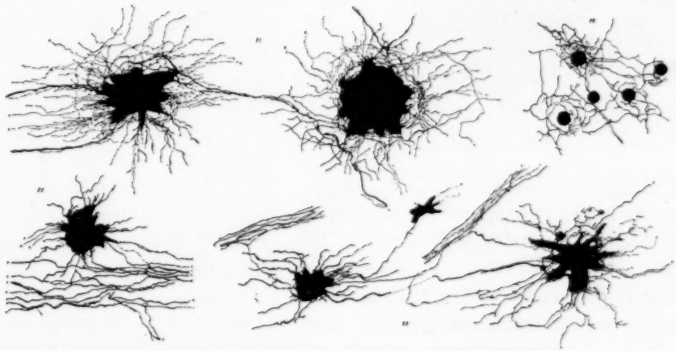

FIG. 2. FISH MELANOPHORES, SOME WITH THEIR PIGMENT DISPERSED, OTHERS WITH IT CONCENTRATED, AND ALL SO STAINED AS TO SHOW INNERVATION
Ballowitz, 1893

tions of so thorough a student of this subject as Professor Giersberg should have led him to this conclusion.

I wish now to present to you work on the color changes in certain fishes which I have done during the last year or so, partly at Woods Hole and partly at Harvard and which not only bears on the question of neurohumors but also opens up further fields of inquiry. I shall speak about the conditions in the dogfish, the catfish, and the killifish.

MECHANISM OF COLOR CHANGES IN THE DOGFISH

The color changes in the common dogfish, *Mustelus canis*, were first studied and described only very recently by Lundstrom and Bard (1932) who found that this fish assumed a light coloration in an illuminated tank with light walls and a dark one in a similar tank with dark walls. These contrasts in color are shown in Figure 6. The various tints of the dogfish's skin according to these investigators depend upon the state of the dermal melanophores. When the pigment granules of these cells are dispersed throughout the bodies of the cells and their processes (Fig. 7), the fish is dark in tone; when they are concentrated near the center of the cell (Fig. 8), the fish is light in color. It was further shown by Lundstrom and Bard that after the pituitary body was removed from the base of the brain of the dogfish, the animal gradually acquired a pallor which began to appear about 30 minutes after the operation and gained a permanent maximum in about 12 hours. This pallor was not apparent when only the anterior lobe of the pituitary body was taken out, but it always appeared after the loss of the neuro-intermediate lobe.

FIG. 3. TWO FROGS OF WHICH THE RIGHT-HAND INDIVIDUAL HAD BEEN INJECTED SIX HOURS PREVIOUSLY WITH PITUITARY EXTRACT AND THE LEFT ONE KEPT LIGHT COLORED AS A CONTROL

Hogben, 1924

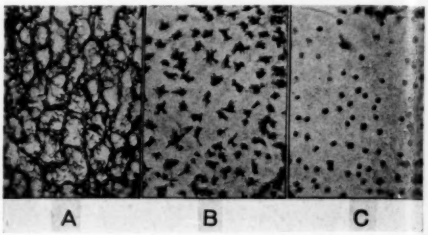

FIG. 4. WEB IN A FROG'S FOOT SHOWING THE MELANOPHORES OF A PIGMENT SPOT IN A DARK CONDITION (A), IN AN INTERMEDIATE ONE (B), AND IN A PALE ONE (C)

Hogben, 1924

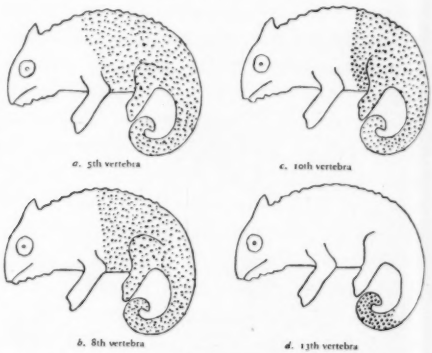

FIG. 5. CHAMELEONS IN WHICH ANTERIOR PALLOR HAD BEEN INDUCED AFTER SEVERANCE OF THE SPINAL CORD IN THE REGION OF THE FIFTH VERTEBRA (A), THE EIGHTH (B), THE TENTH (C), AND THE THIRTEENTH (D)

Hogben and Mirvish, 1928

Hence it was concluded that this lobe, which is believed to be the equivalent of the pars intermedia of the pituitary body in the higher animals, is the structure

FIG. 6. TWO DOGFISHES ORIGINALLY OF THE SAME TINT, TWENTY-FOUR HOURS AFTER THE REMOVAL OF THE HYPOPHYSIS FROM THE FISH ON THE RIGHT. THEY NOW SHOW EXTREME DIFFERENCES IN TINT

Lundstrom and Bard, 1932

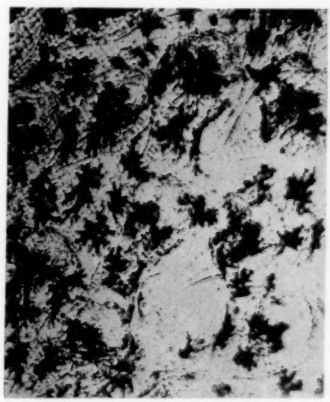

FIG. 7. DERMAL MELANOPHORES OF A DOGFISH SHOWING THEIR PIGMENT IN THAT STATE OF EXTREME DISPERSION WHICH CAUSED THE FISH TO APPEAR DARK

Lundstrom and Bard, 1932

from which emanates the neurohumor concerned with the dispersion of melanophore pigment. This conclusion was confirmed by tests made with fluid extracts from this lobe. When a seawater extract of the neuro-intermediate lobe was injected into a dogfish made light-colored by hypophysectomy, the fish became temporarily dark. This darkening first appeared in about three minutes after the injection was made, reached a maximum in about an hour and disappeared in from five to six hours. Light fishes similarly prepared were temporarily darkened by injections of commercial pituitrin, infundin, and pitressin but not of pitocin.

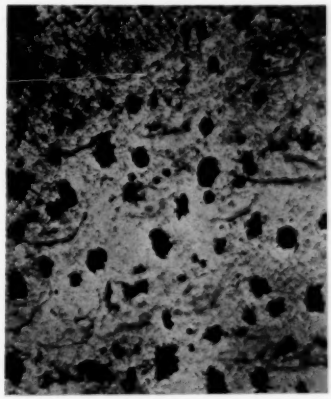

FIG. 8. DERMAL MELANOPHORES OF A DOGFISH SHOWING THEIR PIGMENT IN THAT STATE OF EXTREME CONCENCENTRATION WHICH CAUSED THE FISH TO APPEAR LIGHT

Lundstrom and Bard, 1932

Lundstrom and Bard concluded from these various observations that the pituitary gland, and particularly its neuro-intermediate lobe, produces the hormone that dominates the color changes in the normal dogfish. The dark phase of this fish according to them is the result of a large amount of the appropriate pituitary product in the blood of this animal. The light phase is not especially discussed by them but it is to be inferred from their account that it depends upon the relative absence of the pituitary hormone.

This general conclusion, apparently ade-

quate in itself, may not, however, represent the total situation. Nerves so commonly play a large part in the color changes of fishes that it seemed unwise to accept Lundstrom and Bard's account as complete without first testing the possibility of some form of nervous control. For this reason my assistant, Miss Helen Porter, and I resolved on a further investigation of this subject with the following results.

If in a moderately dark dogfish deep cuts transverse to the rays of any fin are made or similar cuts are inflicted on the body, these cuts give rise to light bands or splotches which are clearly visible in the skin for many hours or even days thereafter. If the spinal cord of a dogfish with the adjacent tissue is transected in the posterior part of the body, the portion of the fish behind the cut becomes irregularly slightly lighter. The light bands are best seen when they are produced on the pectoral fins and are most easily induced by making a well circumscribed cut completely through the fin from one face to the other and at right angles to the rays.

In the pectoral fin the course of the main blood-vessels can be easily seen through the translucent substance of that organ and the cut may be made either distal or proximal to the chief vessels, thus leaving the blood supply to the fin essentially undisturbed. The cut necessarily severs a number of the smaller vessels, but, if its position is well chosen, it can be shown to introduce no serious interference with the circulation. After such a cut has been made a light band quickly develops extending from the cut to the free edge of the fin. This band assumes the width of the cut, never more, and always extends over the fin distally from the cut, never proximally. It follows very closely the lines of the fin rays and their associated nerves. Its detailed nature and fate depend upon the light or dark condition of the dogfish in which it is induced.

In a dark dogfish the band is a lightish area of rather irregular outline (Fig. 9). It is seen with certainty in from ten to fifteen minutes after the cut has been made and it reaches its maximum in about a day. After this it gradually fades out, to disappear completely in from two to three days. A narrow band three to four millimeters wide will, however, disappear in a little over a day; one of a centimeter wide will remain visible for as much as two to three days. The light band fades by being replaced by the dark coloration of the surrounding fin area, the center of the band near the periphery of the fin being the last to disappear (Fig. 10).

In a light dogfish the band is more clearly defined in outline than in a dark one. Its edges are sharply marked and they can be traced from the ends of the cut to near the edge of the fin (Fig. 11). Although the fish may be extremely light in color, the band is always still lighter and agrees in tint with the white border of the fin. Unlike the light band on the dark fish, that on the light fish seems never to be obliterated. At least in all light dogfish kept by us in the laboratory tank the light band has persisted as long as the fish has lived, a period of at most about five days. When from a light dogfish with a light band the eyes are removed the fish darkens and the band eventually disappears as it does in an ordinary dark fish in which it had been induced by a cut.

These light bands give indubitable evidence of the participation of nerves in calling forth the light phase of the dogfish's coloration. The light band resulting from a cut follows exactly the course of the severed nerve-fibers. The severance of these fibers, we believe, throws them into full activity by which their effectors, the melanophores, are made to concen-

trate their pigment completely and to remain in this state for a considerable period. This action on the part of the nerve-fibers appears to persist for as much as five days, an unusual length of time,

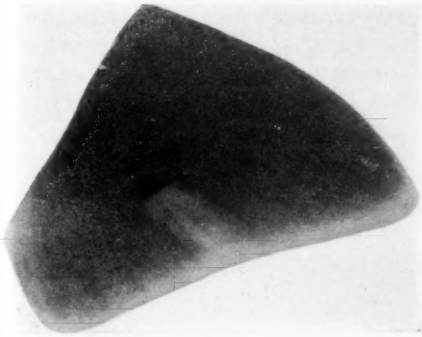

FIG. 9. FIN FROM A DARK DOGFISH SHOWING A LIGHT BAND WHICH RESULTED FROM THE SEVERANCE OF THE FIN RAYS AND THEIR ACCOMPANYING NERVES ABOUT AN HOUR BEFORE THE PREPARATION WAS MADE
Parker and Porter, 1934

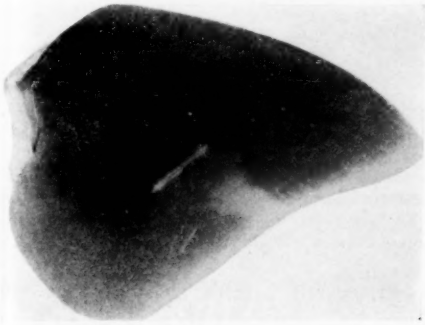

FIG. 10. FIN FROM A DARK DOGFISH SHOWING A LIGHT BAND IN PROCESS OF GRADUAL DISAPPEARANCE THROUGH THE INVASION OF A PITUITARY NEUROHUMOR BY WHICH THE PIGMENT IN THE MELANOPHORES OF THE PROXIMAL PART OF THE BAND WAS DISPERSED
Parker and Porter, 1934

and is overcome only when the dogfish is placed in a dark-walled receptacle. Under these conditions the neurohumor from the pituitary gland enters the blood and as this fluid invades the region of the band the contained neurohumor in steadily increasing amounts must eventually reach the melanophores. Here it finally overcomes the action of the nerve-fibers that bring about a concentration of melanophore pigment and in the end induces the dark phase of the fish by a dispersion of this pigment. This view of the interaction of the dispersing and concentrating factors in the color changes of this fish is supported by the fact that if blood is drawn from a dark dogfish and injected under the skin of a light one, a dark spot

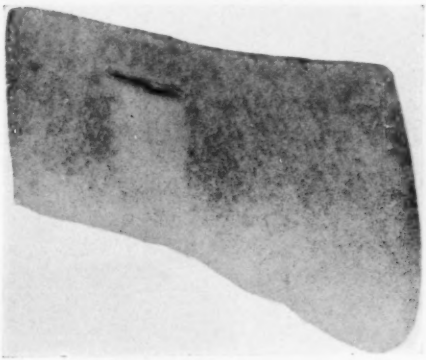

FIG. 11. FIN FROM A LIGHT DOGFISH SHOWING A LIGHT BAND SEVERAL DAYS AFTER THE INDUCING CUT HAD BEEN MADE
Parker and Porter, 1934

quickly appears in the region of the injection and remains there several hours. Blood from a light dogfish, however, has no effect upon the coloration of a dark one and we are therefore led to conclude that there must be a profound difference between the exciting agents of the dark and of the light phases. In the dark phase the pituitary hormone, a dispersing neurohumor, must be soluble in the blood. In the light phase, a state nervously controlled, it is not known with certainty whether there is a neurohumor or not, but if one is involved it must be insoluble in blood. Thus the color changes in the

dogfish appear to be more complex than they were originally supposed to be by Lundstrom and Bard, for in addition to a neurohumoral control of the dark phase by means of a blood-soluble hormone from the neuro-intermediate lobe of the pituitary gland, there is an equally significant nervous control of the light phase, a control that certainly does not involve a blood-soluble neurohumor.

when it is in a similar black walled tank. The extreme differences in these tints are shown in Figure 12. The full change in this fish from light greenish gray to black is slowly accomplished and may require under ordinary circumstances as much as a whole day. The reverse change from black to green-gray is more rapidly tarried out and may be completed in about chree hours. Catfishes whose eyes have

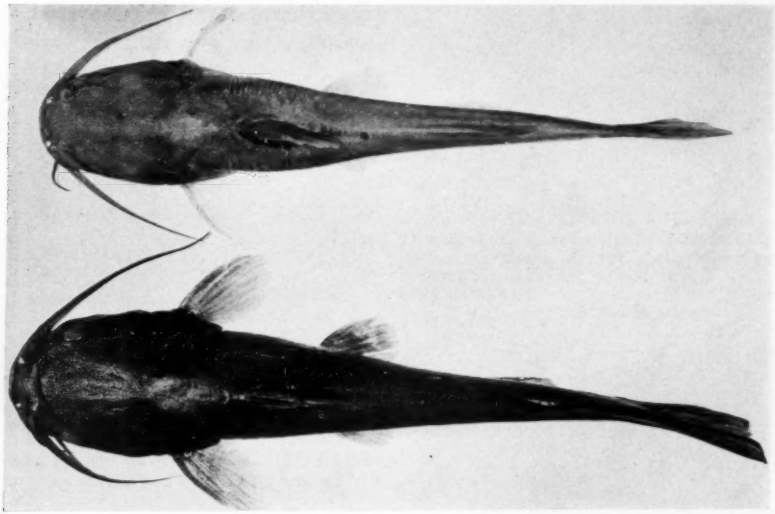

FIG. 12. LIGHT AND DARK CATFISHES SHOWING THE EXTREMES OF TINT ASSUMED BY THESE FISHES WHEN IN AN ILLUMINATED WHITE-WALLED TANK OR IN A SIMILAR BLACK-WALLED ONE
Parker, 1934

MECHANISM OF COLOR CHANGES IN THE CATFISH

The second fish whose chromatophoral activities I wish to discuss is the common freshwater catfish or hornpout, *Ameiurus*. The color changes in this fish have already been studied from a variety of standpoints by Van Heusen (1917), Bray (1918), Pearson (1930), Odiorne (1933) and Bacq (1933). In color change this fish ranges from a light greenish gray when it is in a white illuminated tank to almost black

been securely covered so as to have all light excluded from them or fishes from which the eyes have been excised become almost black and remain so indefinitely. The direct means by which catfishes control the tints of their bodies will now be considered.

The tail of the catfish is a firm membranous structure supported by some fifteen or more bony rays. The caudal nerves pass out into the tail on the lines of these rays. If a ray is cut through

completely the nerves associated with it are severed and the pigment concentrated in the melanophores of the area thus denervated soon spreads out and darkens the whole of each cell. In a little over two hours after such an operation the severed ray is the axis of a band almost black in tint that extends from the cut in the fin to the edge of the tail (Fig. 13). If two adjacent rays are cut, a band of double width is produced. If an uncut

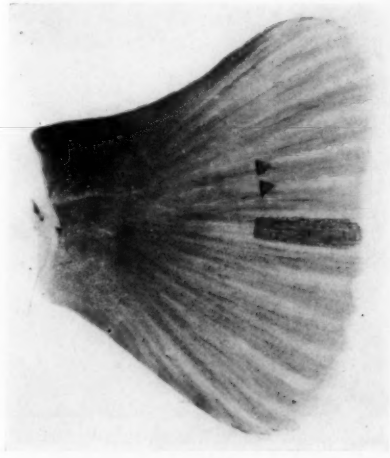

FIG. 13. TAIL OF A CATFISH SHOWING DARK BANDS THAT RESULTED FROM THE TRANSVERSE CUTTING OF RAYS AND DARK TRIANGLES FROM SIMILAR INTERRADIAL CUTS

Parker, 1934

ray intervenes between two cut rays, the uncut ray forms the axis of a light band flanked on each side by a dark one. In such preparations the limits of each band can be seen to be so exactly drawn as to show clearly that the controlling nerve-fibers are very definitely restricted to each band and do not overlap into the adjacent bands. The nerves and their branches in each band have much the form of a feather in which the axis of the feather corresponds to the radial nerves of the fin ray and the side barbs to their lateral branches. The general distribution of several adjacent sets of radial nerves and their branches is such as would be seen if feathers were placed side by side so that the edge of the vane of one feather was just in contact with that of the next one. It follows from this arrangement that if transverse cuts are made in the catfish's tail not through a ray but through the spaces between rays only a small triangular area will be denervated. In consequence only small black triangles should appear in such preparations. Triangles of this kind can easily be demonstrated (Fig. 13). The dark areas produced by the severance of nerves, be they bands or triangles, are when fully formed as near black as the blackest tint of any catfish and show the action of the nerves concerned with the dispersion of the melanophore pigment to be at its maximum.

If in a catfish of intermediate tint a dark radial band is produced by cutting the nerves of one ray, this band will gradually disappear, in part by slowly fading as a whole and in part by shrinkage of area. The band becomes narrower by loss at its edges. This narrowing occurs especially over the proximal extent of the band and becomes complete here before the distal shrinkage has been accomplished. Hence the last of any such band to be seen is its extreme distal tip. Bands produced by cutting single rays in the catfish have been found to disappear in from two to five days. The steps in this process are well shown in Figure 14 where A represents the fully formed band, B the partly shrunken one, and C the last traces of a band.

When the edge of a newly cut band is examined closely under the microscope (Fig. 15), the melanophores with dispersed pigment and constituting the band itself can be sharply distinguished from those with concentrated pigment and

characteristic of the light-colored general surface of the fish. The line of separation between these two kinds of melanophores is a fairly sharp one. But after the band has begun to disappear and particularly after its shrinkage has well started this sharpness disappears and the edge of the band is no longer clearly marked. It is as though some influence that brought about a concentration of the melanophore pigment was making its way from the adjacent lightly tinted region into the body of the band.

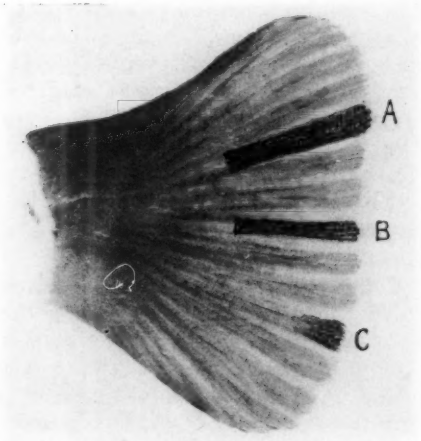

FIG. 14. TAIL OF A CATFISH SHOWING THE FORMATION AND DISAPPEARANCE OF THE DARK BAND

A, a fully developed band three hours after the transverse cut had been made; *B*, a somewhat shrunken band a day or so after the cut had been made; *C*, the last traces of a disappearing band about four days after the cut had been made. Parker, 1934.

The blackish bands just described indicate in a very indubitable way that the catfish possesses melanophore nerve-fibers, the cutting of which induces a pronounced and lasting dispersion of the pigment in the color cells. Further evidence of the presence of these nerve-fibers, which in consequence of their action may be called dispersing fibers, is seen in the responses of the dark bands to adrenalin. If a catfish, in which a newly induced caudal band is fully developed, is injected with an appropriate amount of adrenalin, the whole fish within fifteen minutes becomes very light. This change affects not only the general surface of the fish but the band as well. It is remarkable to watch the rapid and complete disappearance of a band of maximum darkness under the influence of adrenalin. Within three hours after the injection of the adrenalin the effect of this substance begins to wear off and the catfish gradually changes from a very light tint to one of moderate darkness. This final stage is arrived at in about five hours. During this recovery the dark band, at first entirely obliterated, also returns and returns in full intensity. This change indicates quite clearly that though the action of the dispersing nerve-fibers was temporarily overpowered by the adrenalin this action was in no sense brought to a standstill. It must have

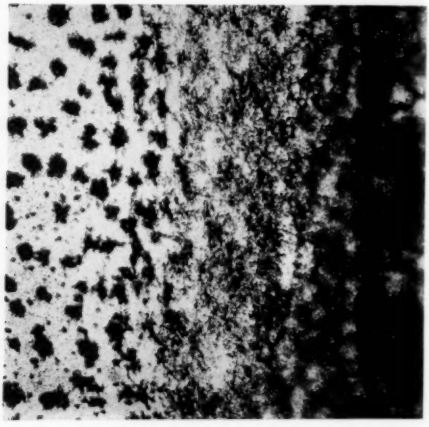

FIG. 15. EDGE OF A RECENTLY INDUCED DARK BAND IN A CATFISH'S TAIL

The contrast between the melanophores with dispersed pigment, which constitute the band itself, and those with concentrated pigment, making up the light area of the fin, is very noticeable. Parker, 1934.

continued unimpeded for as soon as the action of the adrenalin died out the dark band reappeared. Hence it may be concluded not only that catfishes possess dispersing nerve-fibers but that the severance of these fibers is a stimulus to them of lasting quality.

The fact that catfishes are provided with dispersing nerve-fibers is not, however, ground for assuming that these fish may not have other means of inducing the darkened state, such, for instance, as the pituitary secretions. It seemed, therefore, desirable to test the pituitary gland of the catfish in this respect. Four pituitary glands were removed from four freshly killed catfishes, minced in a few drops of Ringer's solution, and 0.2 cc. of this extract were injected into each of several normal catfishes. To this treatment dark catfishes showed no response. Light catfishes on the other hand began to darken within six minutes and were well darkened in twelve minutes. As there were no color changes in either the dark or the light control catfishes injected with simple Ringer's solution, it is concluded that the pituitary glands of the catfish contain a dispersing neurohumor water-soluble in character that may be effective in exciting the dark phase in this fish.

That this pituitary product is active in helping to darken the skin of the catfish can be shown from the following procedure. It is comparatively easy by using the buccal operation devised for this purpose by Matthews (1933) to reach and remove through the roof of the mouth the pituitary gland of the catfish. Fishes thus operated upon may lose very little blood and, notwithstanding the fact that the base of the brain is exposed to the fluids of the mouth, they will live for as long as two days. If a fish with a denervated caudal band which had been cut two days previously and was now well faded, is subjected to the removal of the pituitary gland and placed in a dark-walled illuminated vessel, the following conditions will be observed. The whole fish will be seen to darken except the light band. This will retain its original tint thus showing that in the absence of the pituitary gland a denervated area cannot soon turn dark. Such a condition is in strong contrast with that of a fish which has been treated in all respects like the one just described except that the pituitary gland had been left in the animals. Under such circumstances the light band darkens much as the rest of the fish does, showing that the pituitary hormone in the absence of nerves may play the part of a pigment dispersing agent. It seems clear from these tests that not only does the pituitary gland produce a neurohumor capable of dispersing the pigment in melanophores, but that this neurohumor is soluble in blood and may thus be carried to distant regions of the fish's body. If in a catfish with a denervated band darkened by the pituitary hormone a ray and its associated nerves are cut, a characteristic new band soon appears, a band very much darker than that excited by the pituitary substance. It is therefore apparent that of the two methods of exciting the dispersion of melanophore pigment, dispersing nerves and pituitary hormones, the nerves are much the more effective. It appears then that the dark phase of the catfish is ordinarily brought about by a combination of two factors: first, by the dispersing action on the pigment of the melanophores of nerve-fibers that are specially adapted to this end and that act vigorously, and, secondly, by a much less vigorous hormone from the pituitary gland.

If the dark phase of the catfish's skin is to be explained as has just been set forth, what can be said of the light phase? Does the light phase, for instance, involve

special concentrating nerve-fibers and hormones or is this phase merely that of relaxed quiescence? That nerve action may induce a concentration of melanophore pigment has already been shown for the dogfish so that such an agency is at least possible. Furthermore there are several conditions that point quite obviously to the realization of such a state. The narrowing of the dark band in the course of its disappearance in the tail of a catfish is most naturally accounted for on the assumption of the invasion of the band by a concentrating neurohumor produced by appropriate nerve-fibers in the adjacent light region. As already stated the disappearing dark band narrows as though it were invaded by just such a neurohumor. That there is something to be said for such an assumption may be seen from the following observations.

If a single radial band in a catfish's tail which in the course of a few days has been allowed to become faded is surrounded by two new dark bands situated one on each side and made by cutting the adjacent rays, the intervening light band will gradually become dark (Fig. 16). This darkening will not take place, however, if the intermediate band is not denervated. A normally innervated band between two dark bands as can be made by cutting in a light tail two rays one on either side of a given normal ray, does not in time become dark. Hence whether the intermediate band will become dark or remain light depends upon the absence or the presence of nerves. Its darkening, which occurs when it is denervated, would depend then upon the spread of a dispersing neurohumor from the adjacent dark bands. Such a neurohumor can act with reasonable rapidity on the melanophores of the light band and brings about the dispersion of their pigment. That this does not occur when the light band is innervated is due, I believe, not to the absence in the light band of the dispersing neurohumor but to the presence there of concentrating nerve-fibers whose action overcomes that of the opposing neurohumor and thus the band is kept light. Hence the maintenance of a light normal band as such between two dark bands calls for the

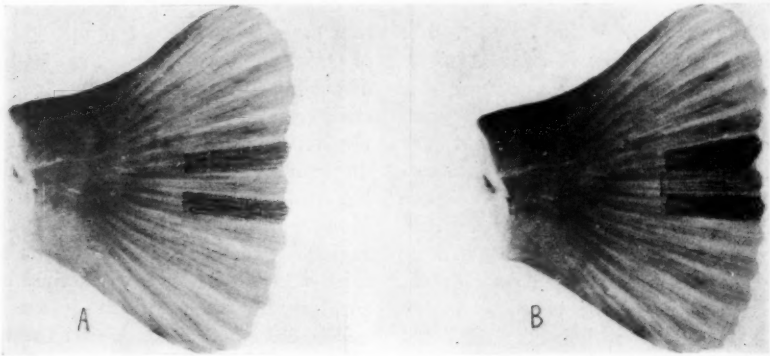

FIG. 16. TWO TAILS OF CATFISHES WITH BANDS ORIGINALLY LIGHT AND INTERVENING IN POSITION BETWEEN TWO DARK BANDS

In *A* the intervening band is still innervated and remains light. In *B* the intervening band, denervated and then allowed to blanch, becomes dark after the formation of the adjacent dark bands. Parker, 1934.

assumption of concentrating nerve-fibers such as occur in the dogfish when a similar opposing action takes place. The concentrating fibers to a certain degree must be subordinate to the dispersing ones, for when a ray is cut both sets of fibers must be severed and thereby stimulated. In the resultant response it is the dispersing and not the concentrating fibers that assert themselves, for the band becomes dark. I therefore conclude that the stimulus of

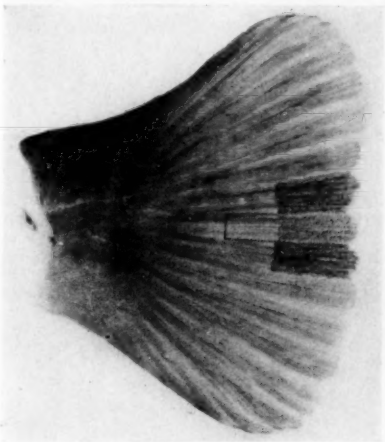

FIG. 17. TAIL OF A CATFISH IN WHICH A DENERVATED LIGHT BAND BECAME DARK IN THAT PART WHICH WAS BETWEEN TWO NEWLY DEVELOPED DARK BANDS

Parker, 1934

cutting the nerve is more effective for the dispersing than for the concentrating nerve-fibers.

The evidence that has thus been advanced for the presence of concentrating nerve-fibers involves the assumption of a dispersing neurohumor whereby a light band is invaded and rendered dark. That such a neurohumor is probably present is seen from another type of band comparison. If in a catfish from which the pituitary gland has been removed and in which a faded radial band has been induced, two new rays are cut so as to bound on each side the distal half only of the faded radial band already formed, this band will in a short time become dark but only in that part which lies between the two new dark bands (Fig. 17). Hence it must be evident that something emanates from these dark bands and induces the darkening of the intermediate one. It is difficult to explain this condition except on the assumption of a dispersing hormone or neurohumor from the adjacent dark bands. I therefore conclude that dispersing nerve-fibers act through a neurohumor that induces both locally and at a distance the dispersion of melanophore pigment. Whether the concentrating fibers act by means of a neurohumor or not is still unsettled.

The following summary may be taken as descriptive of the color changes in the catfish. The dark phase in this fish is induced through dispersing nerve-fibers supplemented by the pituitary gland both acting by means of neurohumors. The light phase cannot be so certainly described, but there is evidence that this phase is dependent upon concentrating nerve-fibers whose action may or may not depend upon neurohumors. The explanation thus advanced implies a double innervation of melanophores. Reasons for the correctness of this assumption will be presented in the discussion of the third and last fish that I wish to consider, namely the killifish, *Fundulus heteroclitus*.

MECHANISM OF COLOR CHANGES IN THE KILLIFISH

The color changes in the killifish have been studied by numerous investigators and over a considerable number of years. Like the catfish the killifish has both a light and a dark phase (Fig. 18). Furthermore small transverse cuts in its tail are followed by the production of dark bands

as in the catfish. In the killifish these bands appear in about half a minute after the cut is made, become strongly pronounced in an hour or so, and then disappear in from two to three days. Such reactions are decidedly more rapid in the killifish than in the catfish though in other respects the color responses of these two fishes are much the same.

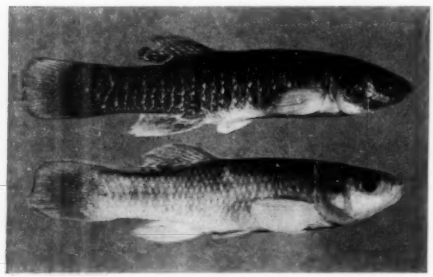

FIG. 18. TWO KILLIFISHES SHOWING IN ONE THE EXTREME DARK PHASE, AND IN THE OTHER THE EXTREME LIGHT PHASE.
Parker, 1934

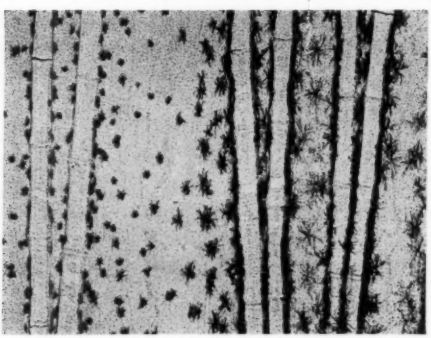

FIG. 19. EDGE OF A DARK BAND IN THE TAIL OF A KILLIFISH HALF AN HOUR AFTER THE BAND HAD BEEN INDUCED BY CUTTING TRANSVERSELY
The contrast between the melanophores with dispersed pigment and those with concentrated pigment is very striking. Parker, 1934.

As already stated, about half a minute after a transverse cut is made in the killifish tail the dark band begins to show. The band then quickly reaches its maximum and at this stage its edges are very sharp. The contrast between the two sets of melanophores at the edge of the band, those with dispersed and those with condensed pigment, is very marked (Fig. 19). After twelve hours this edge has

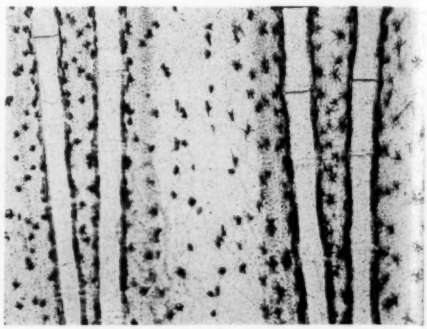

FIG. 20. EDGE OF A DARK BAND IN THE TAIL OF A KILLIFISH 12 HOURS AFTER THE BAND HAD BEEN INDUCED
The sharp contrast between the two sets of melanophores is greatly reduced. Parker, 1934.

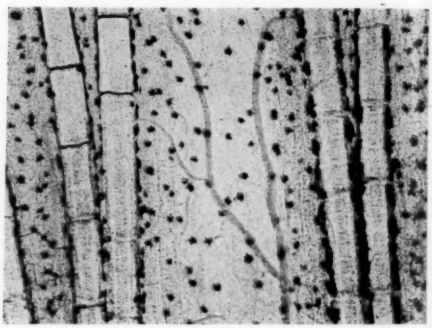

FIG. 21. EDGE OF A DARK BAND IN THE TAIL OF A KILLIFISH 2 DAYS AFTER THE BAND HAD BEEN INDUCED
The original sharp line between the melanophores with dispersed pigment and those with concentrated pigment is quite lost. In this figure the light area in the tail generally is toward the left and the much reduced dark band is toward the right. The pigment in the melanophores at the extreme right of the figure extends somewhat farther into the cell processes than it does in the melanophores of the extreme left. This slight distention is the last trace of the dark band. Parker, 1934.

lost much of its distinctness in that its marginal melanophores have assumed an intermediate state between that of the color cells in the dark part of the band and of those in the light area with transitional melanophores in both directions (Fig. 20). After two days the transition from the dark to the light areas is very gradual indeed (Fig. 21) and its center has shifted well toward the axis of the band. Thus a caudal band in the killifish disappears in the course of time by loss of edge and by gradual shrinkage as it does in the catfish and not through simple disappearance as a whole. It does so presumably from the same cause as in the catfish, for it gives every sign of being invaded laterally by an agent that excites the concentration of melanophore pigment, that is, by a concentrating neurohumor.

After the initial band in *Fundulus* has come to be as light-tinted as the rest of the fish, if the fish is now put in an illuminated dark-walled vessel, the whole animal quickly turns dark except the band which at first remains light and only gradually darkens. The body of the fish reaches a full depth of tint in a little less than two hours but it requires about twenty hours for the light band to accomplish the same degree of change. The reciprocal test yields essentially similar results. If a dark killifish with an equally dark band is put in a light environment, the fish as a whole will turn fully light in a little less than five hours but the stripe will require about twenty-six hours for this change. Thus in both instances the band in changing lags well behind the general surface of the fish as though this surface really was the active agent in the change and the band received from it, depending upon the nature of the change, either a dispersing neurohumor or a condensing one.

In these gradual disappearances of the bands, both light and dark, they are reduced on the edges and not throughout their extent as a whole, thus indicating that the invasion is really a lateral one and not one from the whole under surface of the band. Such a change from below can readily be obtained by adrenalin, for if a killifish with a well developed dark band is injected with this hormone, the band disappears as a whole in less than fifteen minutes and without showing shrinkage at the edge. Adrenalin is soluble in the blood and is carried to the melanophores of the tail by blood and lymph. It bathes the whole deeper surface of any band. Hence its method of approach and the consequent type of disappearance of the band is quite unlike that seen in the natural reactions of the fish where the band diminishes by loss on ite edge and not throughout its whole width at once.

The invasion of the band from its edge is further evident in the times required for the disappearance of initial bands of different widths. Ordinarily bands were produced by a transverse cut of one millimeter extent and under such circumstances the bands disappeared on the average in about thirty hours. But when bands were produced by a two millimeter cut the average time of disappearance was found to be some seventy-eight hours. Such a difference should not appear if the band were invaded from its deeper face as well as from its sides but might be expected if the invasion were strictly lateral. With adrenalin both broad bands and narrow ones disappear in the same time, a little less than fifteen minutes.

The possible effects of the pituitary gland and of the blood on the color changes in *Fundulus* have been investigated by several workers including Mills and Matthews. According to Matthews (1933) the loss of the pituitary gland in

no way prevents *Fundulus* from accomplishing its color changes, though the substance of the gland yields a dispersing neurohumor. Apparently this gland in *Fundulus* is without functional significance as a normal means of controlling color changes.

Tests to ascertain the effect of the blood of *Fundulus* on its melanophores have always given negative results. Mills found that the blood from a dark fish when injected into a light one was without influence on the tint of the animal and the same was true in the converse experiment. My own results confirm those of Mills and hence I conclude that notwithstanding the fact that blood and lymph are the means of carrying adrenalin and other such agents, these fluids are not concerned with the transfer of normal neurohumors whereby the bands in the course of hours are slowly changed either light or dark. These changes require too long a time for accomplishment to be attributed to transfer by blood and lymph and must therefore be carried out in some other way. Moreover the agents concerned attack the bands laterally and not from all sides as lymph-carried materials would. Hence I conclude that in *Fundulus* the melanophores are activated by neurohumors, which are not blood-soluble, and which spread with relative slowness from region to region. Such a condition might well be met by an oil-soluble material which, emanating from the numerous activating nerve-terminals in connection with the melanophores, could spread over the lipoid surfaces of these and other cells and thus induce in distant melanophores responses appropriate to a given general reaction. Such a view appears to be the most probable explanation thus far offered for these complex relations and in this sense it is to be accepted as a working hypothesis. It implies a very close anatomical relationship between the nerve terminals on the one hand and their dependent effectors, the melanophores, on the other, as well as a close mutual relation between the several melanophores or other cells in a denervated region. As a matter of fact such intimacy between cells of this kind has already been demonstrated, for, in a recent paper by Herrick (1932) on the melanophores of the tadpole, it has been shown that the processes of melanophores actually anastomose.

If the interrelation of nerves and melanophores for *Fundulus*, as presented in the preceding paragraph, is sound, as it appears to be, it probably also applies to the catfish, for almost exactly the same situations obtain there as in *Fundulus*. The main exception to this statement is found in the fact that in the catfish in addition to a dispersing and a concentrating neurohumor transferred by the lipoid surfaces of cells there is also a supplementary dispersing neurohumor, the pituitary, carried by the blood and lymph. Thus the catfish is somewhat more complex than *Fundulus*, which in its turn is not as simple as the dogfish. Here, as already made clear, a pituitary neurohumor is the exclusive means of inducing the dark phase. The light phase, however, is controlled by nerves and may well result from a lipoid-soluble neurohumor derived directly from the nerve terminals. From this general standpoint two classes of neurohumors may be distinguished: those soluble in water, that is in blood and lymph, and those soluble in oil such as the lipoid constituents of cells. The water-soluble neurohumors act quickly and on the fish as a whole and the oil-soluble ones slowly and more nearly locally.

Water-soluble neurohumors as seen in

the dogfish and in the catfish act as dispersing agents on the melanophore pigment. The assumed oil-soluble neurohumors on the other hand may act either as concentrating agents on this pigment as in all three fishes under consideration or as dispersing factors as in the catfish and the killifish. Since the oil-soluble neurohumors are always associated with nerves the presence of a concentrating type and a dispersing one in this class is at once suggestive of double innervation. That melanophores are doubly innervated has been suspected since the time of Bert (1875) and has been very recently advocated by Smith (1931) and especially by Mills (1932). Smith has shown in *Fundulus* that cocaine, a sympathetic stimulant, induces concentration of pigment in melanophores, and that ergot, a sympathetic depressant, checks this operation. On the other hand pilocarpin, a parasympathetic stimulant, induces dispersion of the pigment and atropin, a parasympathetic depressant, checks dispersion. These results point distinctly toward the double innervation of melanophores, a view to which Mills was led on evidence of an entirely different kind. Mills showed that if the exact distribution of the light and the dark melanophores on the edge of a caudal band is recorded when the whole fish is quickly induced to take on first the light and then the dark tint the two distributions do not agree. In consequence of this lack of agreement two sets of nerve-fibers are to be inferred, one concerned with the dispersion of the melanophore pigment and the other with its concentration. These observations seem to me to afford very substantial support to the idea of double melanophore innervation in which, to use the conventional phraseology, the fibers concerned with pigment concentration would be classed as sympathetic and those concerned with dispersion as parasympathetic.

CELL-TO-CELL TRANSFER OF SUBSTANCES

The passage of oil-soluble neurohumors gives evidence of a somewhat unsuspected method of transfer of materials within the body of an organism, namely, a transfer from cell to cell. Although this method of the translocation of substances has received only scant attention from biologists, it appears on even a superficial inquiry to be widely spread and, as the following brief survey will show, to be of no small significance.

FIG. 22. TISSUE ON THE EDGE OF A TENTACLE OF DROSERA SHOWING A SO-CALLED BUD (B) THROUGH WHICH CAFFEIN HAS MADE ITS WAY INTO THE ADJACENT CELLS AND PASSED TRANSVERSELY AND LONGITUDINALLY THROUGH THE TISSUE AS INDICATED BY THE PARTICLES OF PRECIPITATE SHOWN IN MANY OF THE CELLS

Kok, 1932

Cell-to-cell transfer is known to occur in plants and has been studied recently by Kok (1932). This investigator has shown among other instances that in the tentacles of *Drosera* the so-called buds mark superficial spots at which caffein can gain entrance to the underlying tissues whence this drug may spread not only transversely but also distally and proximally through the tentacles (Fig. 22). This transfer of caffein can be followed from cell to cell in consequence of a precipitate formed in each cell as the drug progresses and its rate has been thus measured by Kok. In the distal direction the caffein was estimated to travel 658 microns in 30 minutes and in a proximal one 534 microns in the same period. This progression is at a much greater rate than

that which I have found for the neurohumor of the killifish, namely 9 microns in 30 minutes. The important point in the observations by Kok is the direct evidence of a transfer and from cell to cell, a determination which was only indirectly arrived at in *Fundulus*.

Similar slow transfers have been recorded by Sir Thomas Lewis (1927) in the human skin. If the skin of the forearm of a human being (Fig. 23) is irradiated over a sharply circumscribed area for a brief period of time, an artificial "sunburn" is produced which appears as a reddened patch with sharply marked limits. The reddening is of course due to the enlargement of the subjacent blood-vessels. These vessels respond to the treatment as though they had been acted upon by histamine, and Sir Thomas attributes their enlargement to the local liberation from the irradiated cells of a substance, possibly histamine itself, but which he prefers to call H-substance. In about a day after the irradiation the edges of the reddened area and the redness spread into the adjacent unaffected skin, indicating a slow transfer of the H-substance from the region of production into the originally undisturbed area. This spread occurs within a period of from twenty to twenty-four hours and over a distance of from two to three millimeters after weak irradiation, of from four to five millimeters after a strong one. The rates obtained from these figures for the spread of the so-called H-substance are roughly 40 to 100 microns in 30 minutes, approximately midway between those established for *Drosera* (approximately 600 microns in 30 minutes) and for the killifish (about nine microns in 30 minutes). The agreement of these rates, rough though it may be, shows, I believe, that in these and other like instances we are dealing with a common method of material transfer

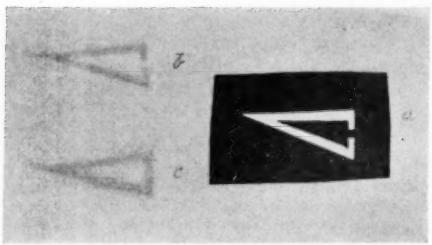

FIG. 23. FOREARM OF A HUMAN BEING WITH A METAL SHIELD (A) THROUGH WHICH A PATTERN HAS BEEN CUT FOR USE IN IRRADIATION EXPERIMENTS, WITH A FRESH "BURN" (B) SHOWING RELATIVELY SHARP EDGES PRODUCED BY IRRADIATING THE SKIN THROUGH THE OPENING IN THE METAL SHIELD AND WITH AN OLD "BURN" (C) SHOWING SPREAD AND INDISTINCTNESS OF EDGE

Lewis, 1927

FIG. 24. PIEBALD SKIN OR VITILIGO IN A YOUNG MAN

Sutton, 1928

which from its cellular nature is bound to be in all respects slow.

Other sluggish, localized transmissions through the human skin are seen in the spread of gurry sores or erysipeloids. These are sores that occur on the hands of butchers and those who clean fish. They start from slight skin abrasions whence they spread slowly over considerable areas.

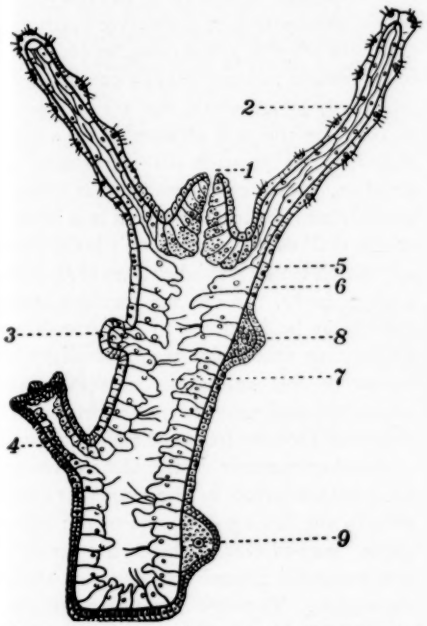

FIG. 25. DIAGRAM OF A LONGITUDINAL SECTION OF A HYDRA SHOWING THE MOUTH (1) LEADING INTO THE DIGESTIVE SAC AND THE SURROUNDING CELLULAR WALLS

They are apparently not due to infection by germs but to the continuous invasion of the initial abrasion by the decomposition products, probably ptomaines, from meat or the gurry of the fish market. They quickly heal and disappear when the hands of the worker are kept from the offal of the butcher shop. The spread of these sores under continual exposure is so slow as to recall the cell-to-cell transmission already described. Many insect stings follow the same course and spread through the human skin a centimeter or so in several days, finally to retreat slowly to the original center of disturbance. Much the same type of slow spread is

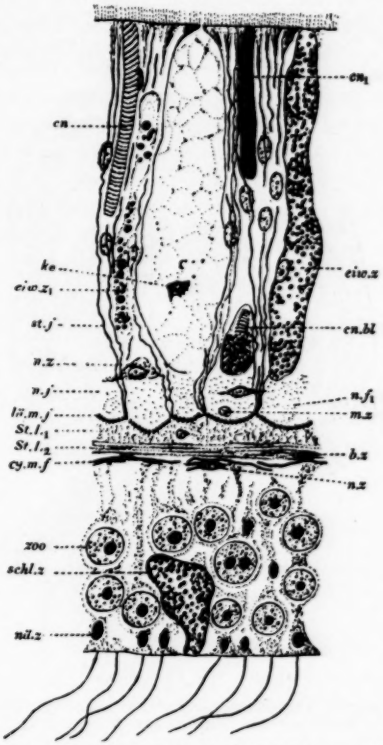

FIG. 26. SECTION THROUGH THE BODY-WALL OF A SEA-ANEMONE SHOWING THE ENTODERMIC LAYER BELOW AND THE ECTODERMIC LAYER ABOVE WITH ITS MUSCLE CELLS (M.Z), NERVE CELLS (N.Z.), GLAND CELLS (EIW.Z.), NETTLE CELLS (C.N.) AND THE LIKE

seen in human piebald skin or vitiligo (Fig. 24). The disease, which is far from being understood, creeps over the skin at so slow a rate as to place it possibly in another category of changes from those already discussed. It is, however, interesting as an instance of slow dermal transmission.

Not only is there evidence of sluggish cellular spread of materials among the tissues of the more complex animals including man but such processes appear to be strikingly characteristic of many simple multicellular forms such as the hydra, the sea-anemone, and the whole group of coelenterates. In these animals, as can be clearly seen in the hydra (Fig. 25)

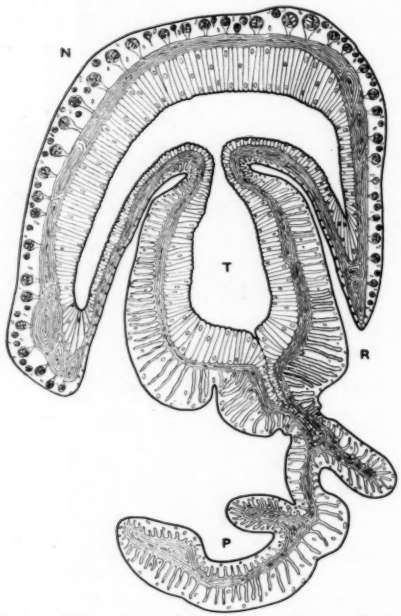

FIG. 27. TRANSVERSE SECTION OF A FISHING FILAMENT OF THE PORTUGUESE MAN-OF-WAR

T, central canal for digestive products; *P*, muscle plate.

many cells are remote from the sources of food supply. In the hydra the food is passed by the tentacles into the mouth and thence to the digestive sac which is the only open space within the animal's body. From this sac the products of digestion must reach even the most distantly situated living cells of this simple organism. The only cells that are in a position to profit at once by this supply of food are those that bound the digestive space, the entoderm cells. All other cells are at a distance from this supply and as the creature has no circulatory system by which to spread the products of its digestion, these products must be handed on from cell to cell till a sufficiency has reached the most remote elements. Consequently the deep-lying entoderm cells not in contact with the digestive cavity, the entodermic muscle cells, and the whole ectodermic system of protective epithelial cells, nettle cells, gland cells, reproductive cells, muscle and nerve cells can be nourished only by materials that are handed on to them by the cells situated more advantageously in relation to the source of supplies. How considerable this cellular transfer must be is clearly seen in a section of the wall of a sea-anemone's body (Fig. 26) which is much thicker than that of the hydra's body. In the sea-anemone many cells must be involved in the transfer of nourishing materials from the digestive cavity of this animal to its remote elements situated near its outer surfaces and therefore farthest from the source of food.

Another example of the same extensive food transmission in the coelenterates is seen in the fishing filaments of the Portuguese man-of-war. These filaments in this beautiful animal may be many meters in length. Through the center of each one (Fig. 27) runs a canal by which digestive products from the digestive cavity of the polyp may be carried out to the most remote parts of the filament and yet when these products reach the more peripheral regions they are still relatively far from the cells that they must nourish. Many intervening cells lie between the muscles of the filaments, for instance, and the nutritive canal. When it is recalled that muscle is perhaps one of the most actively metabolic tissues of any animal and that in this instance, as shown in the transverse section of the filament (Fig. 27), this

tissue is much of it very remote from the source of food supply in the central canal, it must be at once appreciated how important and significant cellular transmission is. Thus the coelenterates afford examples in which cell-to-cell transfer is apparently a vastly more vital element in their economy than it is in the more complex creatures, and nevertheless there is good reason to assume that this type of transfer has been retained even in such complexly organized animals as man.

In conclusion it may be stated as a result of this survey that there is ample support for the opinion that substances are transmitted through the bodies of plants and of animals not only by blood, lymph and other similar fluids, but from cell to cell. This method of transmission is believed to occur in organisms from the simplest to the most complex. It is of course much more primitive than that of blood and lymph. In itself it is a relatively slow process but it operates often in connection with other more rapid types of transfer. It is probably an important factor in many of the remarkable operations which take place in embryonic and regenerative growth where transfer of material from one spot to another, as is implied, for instance, in the modern theory of the organizer, takes place.

REDUPLICATION IN EVOLUTION

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INTRODUCTION

IN 1894 William Bateson published his classic work *Materials for the Study of Variation*, in which he stressed the fundamentally important concept that the existence of patterns, defined as exhibiting symmetry with respect to certain points and axes, is a central fact of morphology. He distinguished 'Minor Symmetries,' formed by patterns completed in the several organs or parts, and 'Major Symmetries' which are compounded of minor symmetries. He proposed the term 'Merism' to include the phenomenon of 'Repetition of Parts' in organisms, "generally occurring in such a way as to form a Symmetry or Pattern"; and he noted that this phenomenon "comes near to being a universal character of the bodies of living things."

He then continued to distinguish two main kinds of variations, namely, 'Meristic Variations' and 'Substantive Variations.' As an example of meristic variation he cited the fact that the flower of a *Narcissus* is commonly divided into six parts but through meristic variation it may be divided into seven parts or into only four. As an example of a substantive variation he cites the occurrence of two distinct colors in different species of *Narcissus*.

Bateson, however, considered variability only in its present manifestations. Owing to his reaction against phylogenetic speculation, the chronological or phylogenetic aspect of variability was practically banned by him, especially in his famous Address before the British Association for the Advancement of Science at Toronto in 1914. In the present paper, on the contrary, certain phases of variability, hereinafter named *polyisomerism* and *anisomerism*, are considered from the phylogenetic viewpoint, in which the available facts of geology, palæontology and zoology are, so far as possible, constantly integrated.

REDUPLICATION AND INEQUALIZATION IN INVERTEBRATES

Trilobites, Crustaceans, Arthropods

The researches of palæontologists, especially those of Walcott, Beecher, Raymond and Leif Störmer (1933) have shown that some of the Cambrian trilobites, including *Triarthrus* (Fig. 1A) were remarkably generalized animals that were apparently near to the direct ancestors of the eurypterids, king crabs (*Limulus*), scorpions and spiders. In another direction they were elated to the ancestors of the Crustacea. The thorax of normal trilobites consists of numerous segments, each of which bears on either side a jointed and usually biramous appendage; each of these paired appendages includes a basal piece or coxopodite from which branch outward two main divisions, an exopodite and an endopodite. The endopodites were used for crawling and consisted usually of six joints. The jointed exopodites were biramous distally, the posterior branch bearing a row of closely appressed gill-blades (Leif Störmer). In any individual trilobite the parts of one thoracic segment are severally comparable with those of other segments. The limbs of crustaceans, according to Leif Störmer, lack the gill-blades of the primitive exopodite, which are preserved in the

more primitive arthropods (e.g., *Limulus*). Thus the common trilobite-crustacean stock is probably Pre-Cambrian in origin.

Trilobites, crustaceans, arthropods, as well as annelid worms, are metameric animals, in so far as they present an anteroposterior series of homologous segments of budding or subdivision of some parent substance or tissue. Polyisomeres are homologous or comparable parts, either in the same or in different segments or organs, e.g., the different individual gill-blades of a trilobite, either of a single segment or as between different segments.

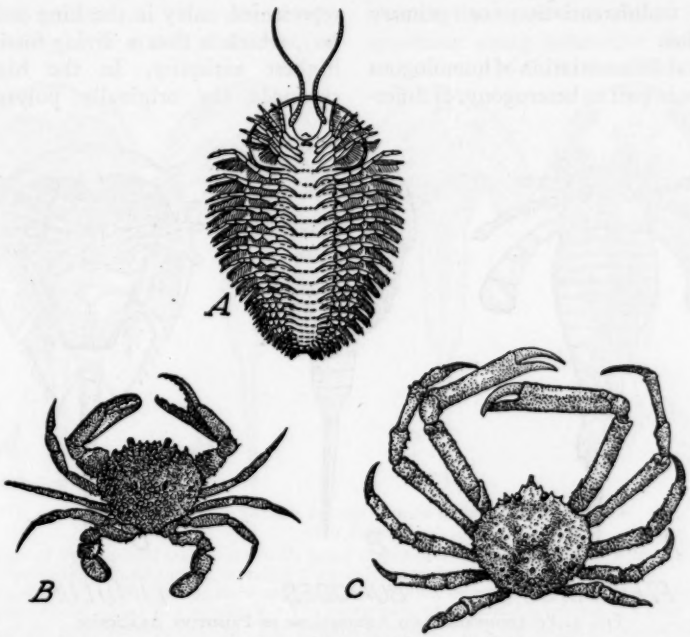

FIG. 1. POLYISOMERISM AND ITS OPPOSITE, ANISOMERISM, IN METAMERIC INVERTEBRATES

A. Primitive Cambrian trilobite, *Triarthrus beckii*. After Beecher. Under side, showing primitive longitudinal and transverse polyisomerism.

B. Modern crab (*Platyonichus ocellatus*). After A. G. Mayer. Dorsal side, showing high degree of anisomerism.

C. Spider crab (*Libinia dubia*). After A. G. Mayer. Dorsal side, showing secondary polyisomerism by convergence.

extending symmetrically on either side of the long axis of the body. Metamerism is, however, only a special case of polyisomerism, or reduplication, which may be defined as the state in which many homologous parts are arranged along any primary or secondary axis, anteroposterior, transverse, vertical, spiral, etc. Polyisomerism evidently results from a process Thus we may have interorganic polyisomerism or intraorganic polyisomerism.

If we now compare a modern lady-crab (*Platyonichus ocellatus*, Fig. 1B) with the primitive trilobite, we shall note that in the crab a number of the thoracic segments have fused with the head to form a cephalo-thorax, while the appendages have acquired a marked regional differen-

tiation, so that, for example, the powerful claws armed with sharp tooth-like projections on their "jaws" are quite different in general appearance from the walking legs and these again from the paddle-like appendages at the rear end. Here then is an example of true differentiation or *anisomerism*, which has grown out of a state of undifferentiation or primary *polyisomerism*.

Such local differentiation of homologous parts is due in part to heterogony, or differences in growth rates in different segments as compared with the body as a whole (J. S. Huxley, 1932, p. 8).

If next we compare an ordinary crab with a spider crab (Fig. 1C) we note that in the latter the exoskeleton is covered with numerous small excrescences and that the very long appendages in a general way look much alike, so that the really high specialization of this form is masked by a false impression of uniformity or lack of differentiation. This is an example of secondary polyisomerism by convergence of a type which is extremely frequent throughout the animal and plant kingdoms.

There seems to be good evidence that the trilobite stock gave rise to the Silurian eurypterids and that some of these in turn produced the Silurian and later scorpions and spiders, while certain others are represented today in the king crab (*Limulus*), which is thus a 'living fossil' of the highest antiquity. In the higher arthropods the originally polyisomerous head segments become variously fused and distorted in connection with the great enlargement of the paired cranial ganglia and their partial concrescence into a true brain. A similar fusion of primitive neuromeres has generally been supposed by embryologists to have taken place in the remote ancestors of the vertebrates. For this and other reasons the late Professor William Patten (1912) brigaded the Arthropoda and the Vertebrata in a superphylum which he named the Syncephalata.

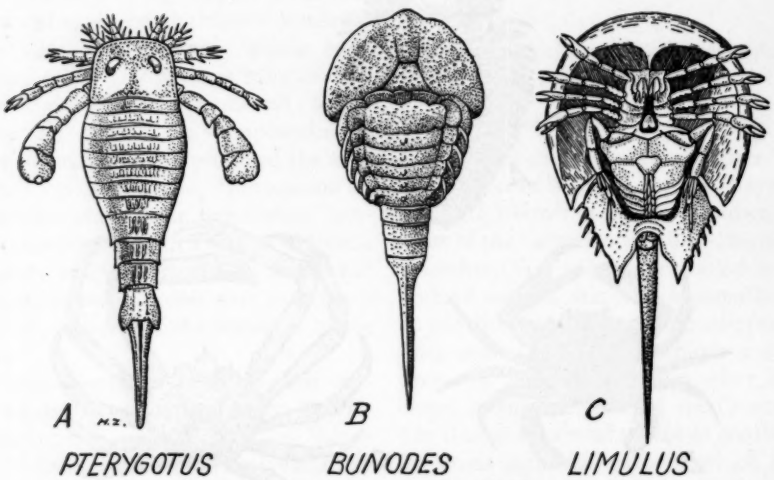

FIG. 2. POLYISOMERISM AND ANISOMERISM IN PRIMITIVE ARACHNIDS

A. Pterygotus anglicus. From Abel, after H. Woodward.
B. Bunodes lunula. After restoration by Patten.
C. Limulus polyphemus. After Abel. Under side, showing anisomerism of head-shield and thorax.

He also showed how (Fig. 3), according to his theory, the shield and paired eyes of the primitive eurypterid grew around on to the opposite side of the animal and the eyes turned inside out to produce the paired eyes of the earliest ostracoderms; how the several cranial nerves of the arachnids were transformed into those of the typical vertebrates. But after many years of fairly frequent and close study of

To palæontologists both Patten's and Gaskell's theories must stand at present as capital examples of the power of convergence and of mere coincidence to produce deceptive similarities between widely unrelated forms. In other words, it appears that independently in the Arthropoda and in the Chordata the progressive evolution of a complex locomotor apparatus along somewhat similar lines

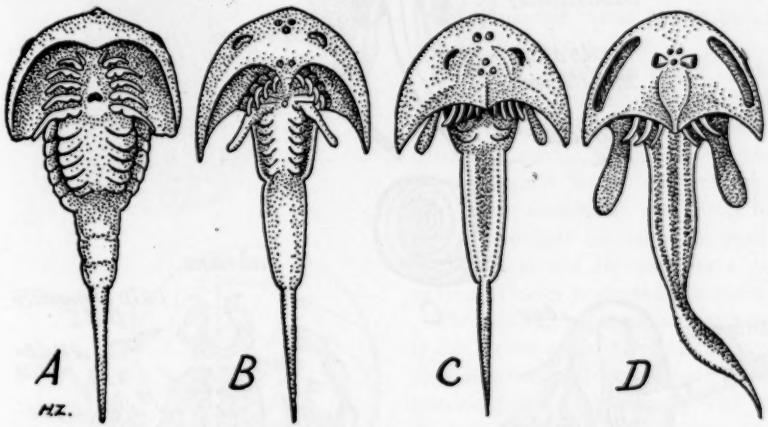

FIG. 3. PATTEN'S THEORY OF THE ORIGIN OF THE VERTEBRATES
After Patten

A. Diagram of hypothetical marine arachnid, based chiefly on *Bunodes lunula*. The animal is lying on its "back," or functionally dorsal surface, revealing the primitive mouth and paired appendages.

B, C. Hypothetical stages showing the overgrowth of the shield on to the originally ventral surface, which gives rise to the dorsal surface of a vertebrate. The overgrowth of the shield is referred to a great increase and coalescence of the neuromeres beneath it. The cephalic appendages give rise to the extrabranchial cartilages and postoccipital appendages.

D. Larval ostracoderm (*Cephalaspis*), showing complete transmigration of the shield and paired eyes on to the now dorsal surface.

From the palæontological viewpoint there is little warrant for the postulation of either such a major shift of the shield or the derivation of the vertebrate branchial skeleton from cephalic appendages.

Professor Patten's theory I am unable to accept his proposed homologies between the cranial nerves of arachnids and those of vertebrates. Gaskell's version of the arthropod theory of the origin of vertebrates, while equally ingenious, requires even greater demands upon our credulity in accepting its drastic transformations of the primitive gut of arthropods into the lining of the neural tube of vertebrates (cf. Delage and Hérouard, 1898, p. 350).

required a more and more complex control system; that is, a primitive state of polyisomerism in the locomotor parts and their corresponding nerve segments, through emphasis, concrescence and loss of parts, gradually gave way to differentiation or anisomerism in both phyla. But in spite of the convergence in external appearance between eurypterids and ostracoderms it must be admitted that the brain and cranial nerves of *Limulus* are

profoundly different from those of the larval lamprey or even from those of the Devonian ostracoderms as described by Stensiö.

The mouth-parts of invertebrates show the same principles of growth and evolution as do their varied locomotor apparatus. Perhaps the simplest forerunners of jaw-parts are the ciliated bands which in various Protozoa and in the larvae of annelids, echinoderms, etc., serve to drive a current of water into the mouth. Here the polyisomerism of the cilia is evident.

The starting-point for the more or less complex jaw-parts of crustaceans, arachnids and insects is to be seen in the much more primitive conditions in trilobites, where the functional jaws are merely the proximal parts of the first two pairs of segmental appendages.

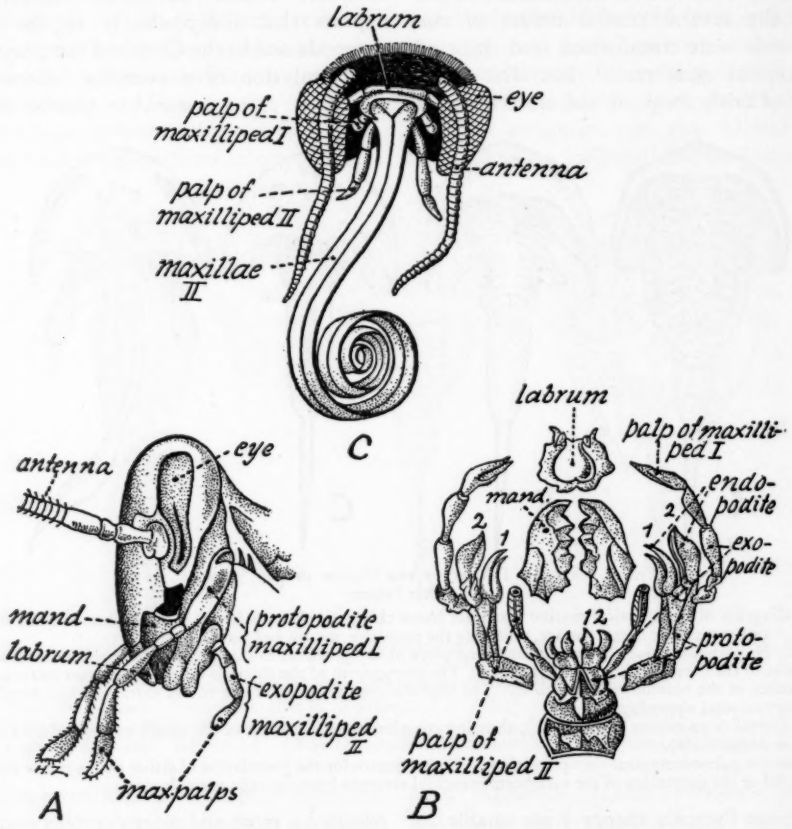

FIG. 4. POLYISOMERISM AND ANISOMERISM IN THE MOUTH PARTS OF INSECTS
Modified from Parker and Haswell, after Lang

A. Head of cockroach, showing maxillary palps derived from exopodites of cephalic appendages.
B. Mouth parts of cockroach, showing primitive relations of exopodites and endopodites to protopodites.
C. Extreme anisomerism in mouth parts of Lepidoptera, showing proboscis made up of the fused endopodites (maxillæ) of "maxilliped II."

It has long been known that among the insects there are many steps from the primitively isomerous mouth-parts of the cockroaches (Fig. 4A, B) to the excessively specialized anisomerous mouth-parts of the Lepidoptera (Fig. 4C).

Molluscs

Although molluscs are not metameric animals they often display serial repetitions of certain features which are an expression of the phenomenon here called secondary polyisomerism, following upon an earlier anisomerism: for example, the ridges or folding of the shells of many pelecypods or the eyes on the mantle of scallops. Such alternate elevations and depressions imply temporal acceleration of growth and spatial distribution of neutral nodes, which processes seem to be among the causes of polyisomerism. Secondary polyisomerism is beautifully illustrated in the successive chambers of cephalopods. In the more elaborate types of sutures of fossil nautiloid shells we witness the evolution of polyisomerism of the second, third and even higher orders.

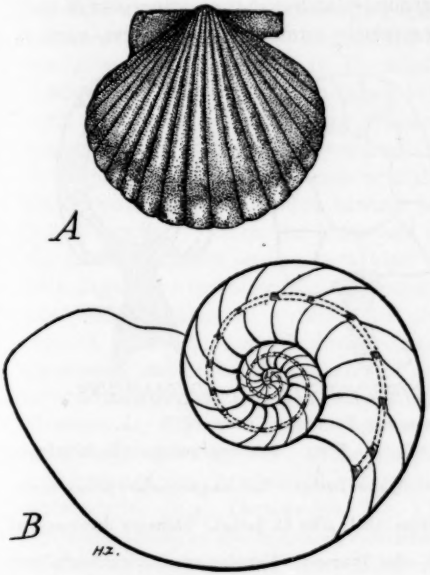

FIG. 5. SECONDARY POLYISOMERISM IN MOLLUSCS

A. Radial polyisomerism in *Pecten*. After A. G. Mayer.

B. Spiral polyisomerism in *Nautilus*. Section of shell, after Parker and Haswell.

There seems to be good evidence that the primitive mollusc was bilaterally symmetrical until a constant difference in growth rates of the two sides of the mantle conditioned what might be called a spiral symmetry.

Thus polyisomerism is due to the summation of rhythmic pulses of growth operating in tissues of more or less homogeneous material, i.e., in any of the three primary germ layers or their products. Hence polyisomerism, as a direct result of rhythm in cell division, is perhaps as fundamental and far-reaching a property of living things as growth and subdivision.

The opposite phenomenon, anisomerism, is due to the undue emphasis or prolongation of growth of certain parts, which are thus thrown out of harmony with the rest. A more remote contributing cause of polyisomerism and its opposite may be the diurnal and seasonal variations in the environment, as clearly registered in the lines of growth in shells, fish scales and tree trunks.

The highly organized radula, or rasp, of predatory molluscs includes a great number of tiny denticles arranged in various ways in longitudinal rows on a movable, strap-like tongue, which can be jerked back and forth over the shell of the victim. These polyisomerous denticles are also diagnostic in different species and genera, and here we notice the obvious but fundamentally important fact that polyisomeres are always specific or even individual, so that although the processes that produce polyisomerism may be similar or identical in different cases, the material that goes

into the product is always specific and diagnostic, possibly even of the individual, if sufficiently delicate tests of age and nutritional factors were available.

Echinoderms

The combined results of long periods of polyisomerism, anisomerism and secondary polyisomerism in the arthropod group and their allies have produced many extraordinary types of body, but in the echinoderms still more amazing transformations have been attained by the accumulation of an infinite number of small steps. On account of the bilaterality of the larva of *Antedon* it is believed by high authorities that the radiate symmetry of echinoderms was first developed in adaptation to sessile life by an early bilateral and free-moving pre-echinoderm. While that may well be true of the pre-echinoderms, by the time the echinoderms themselves first became known in geological history they were already attached forms and it is even possible that some of the early sea-lilies with five well developed "arms" may be more primitive than the asymmetrical bag-like *Aristocystites*. These five arms, which were of course primarily like the puckered corners of the bell-like mouth of a jelly-fish, were of great functional importance in collecting and passing along minute food particles to the mouth. From the first they exhibited a pentameral polyisomerism, not only in respect to their general ground-plan but in the comparison of their extremely numerous small parts, such as the tube-feet, ampullæ and supporting plates. Contact of the larva with the ground, however, induced a marked regional anisomerism manifested by the outgrowth of an attaching organ or stalk, which eventually in its turn became secondarily polyisomerous.

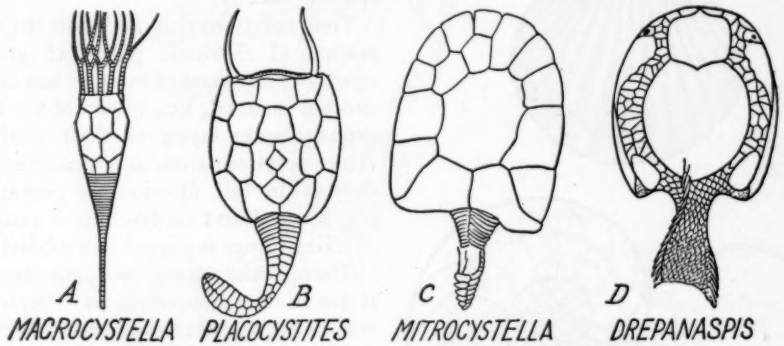

FIG. 6. COMPARISON OF ECHINODERMS AND PRIMITIVE CHORDATE

A. Relatively primitive cystoid, *Macrocystella*. After E. W. Berry. Showing quinqueradiate polyisomerism.

B. Upper Silurian carpoid, *Placocystites forbesi*. From Abel, after Bather. Showing secondary dorso-ventral asymmetry and bilateral symmetry.

C. Lower Silurian carpoid, *Mitrocystella barrandei*. From Abel, after O. Jaekel. Showing dorso-ventral asymmetry and incomplete bilaterality.

D. Devonian ostracoderm, *Drepanaspis*. From Zittel, after Traquair. Showing nearly complete bilaterality.

However, with the instability and as it were recklessness that characterizes Nature, some of the beautiful sea-lilies sacrificed their five-rayed symmetry by habitually bending over on one side. As the calyx touched the bottom on one

side and the race gradually became adjusted to this new position, a dorso-ventral asymmetry was gradually imposed, together with a cephalo-caudal asymmetry and eventually a bilateral symmetry. Several stages in this process are seen in the early group of echinoderms called Carpoidea. Thanks chiefly to the researches of Bather in England and Jaekel in Germany, many genera of these queer lop-sided creatures have been made known to science and an excellent brief review of the group may be found in O. Abel's *Lehrbuch der Paläontologie* (1920, pp. 280, 281). When the calyx was bent over and acquired a dorso-ventral asymmetry it developed a bilateral articulation with the stalk, which in turn tended toward bilateral symmetry, while the lower end of the latter, formerly serving as a kind of root, acquired a spatulate, tail-like expansion. Meanwhile, as a result of the induced tendency toward dorso-ventral asymmetry and bilateral symmetry of the calyx, certain genera (e.g., *Placocystites*, *Mitrocystella*, Fig. 6) began to display a somewhat vague suggestion of the general appearance of the "head shield" of certain ostracoderms (e.g., *Drepanaspis*, Fig. 6), while the stalk, as above noted, furnishes an amusing suggestion of an ostracoderm tail.

In another carpoid named *Cothurnocystis* the calyx is markedly asymmetrical, bearing on one side a row of small openings (Fig. 7) which Dr. Torsten Gislén (1930) has compared with the asymmetrical gill-openings of the larva of *Amphioxus*.

Of course we cannot yet be sure that all these resemblances are not due to the "long arm of coincidence," which has brought about hosts of what the late Professor Bashford Dean (1908) called "Unnatural History Resemblances," such as the "crucifix" on the underside of the skull of certain catfishes, the "samurai's face" on the back of certain Japanese crabs and the "Arabic inscription" on the tail of a certain fish. And whenever such spurious resemblances are pointed out the memory is quick to supply additional "evidence" from independent quarters. So also in the case of the ostracoderm-like appearance of some of the carpoid echinoderms we recall that zoölogists have long suspected that there was a remote connection between the echinoderms and the vertebrates, not only because of the "*Tornaria*" larva of *Balanoglossus*, which resembles that of certain echinoderms, but also because both form their mesoderm from enterocoelic pouches.

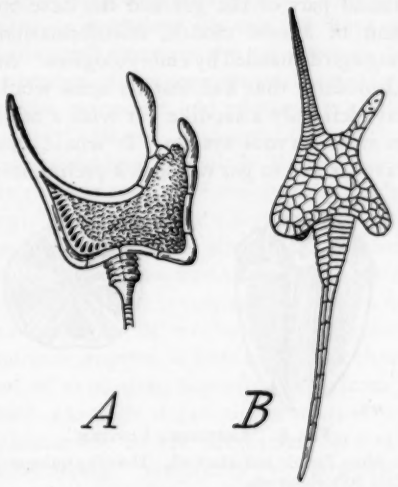

FIG. 7. ASYMMETRICAL SILURIAN CARPOIDS
From Abel, after Bather

A. Cothurnocystis elizae. Showing marked asymmetry and supposed "mouth openings" (? branchial openings).

B. Dendrocystites scoticus. Showing tail-like stalk. The marked asymmetry and general appearance is somewhat suggestive of an ascidian larva.

Meanwhile it must be admitted that so far as known there is a profound morphological gap between any known echinoderm and the oldest known vertebrates. This would be still more con-

spicuous if proof were found for Jaekel's view (quoted by Abel, 1920, p. 279) that the reduction of the mouth-plate in the carpoids is correlated with the evagination of the gut in front of the mouth, as occasionally happens in the holothurians, so that the food was both caught and digested outside the body! Nevertheless even greater miracles seem to have happened than the hypothetical loss of the preoral part of the gut and the development of a new mouth, transformations long ago demanded by embryologists. An echinoderm that had lost its arms would have left only a sac-like gut with a minimum of nervous system. It would thus have far less to get rid of as a preliminary

FIG. 8. "ARISTOTLE'S LANTERN"

After Parker and Haswell. Showing quinqueradiate polyisomerism

before starting on the upward road to the vertebrates than would the far more highly organized arthropods.

Consequently the nascent "Carpoid theory" of the origin of the vertebrates, which no one except Dr. Torsten Gislén has as yet had the courage even to imply, may eventually prove to be the final key to the classical problem of the origin of the vertebrates.

We have already noted that the five arms of primitive sea-lilies are practically projecting folds around the mouth. Thus the tube-feet in the "arms" of the starfishes now serve as locomotor organs by a change of function.

The beautiful mechanism known as Aristotle's lantern in the sea-urchin is made up of five sets of tooth-like plates with several rows of supporting plates and lever arms, operated by five principal muscles and a number of accessory muscles and their controlling nerves—all set in a ring around the mouth. If taken to pieces by an amateur this amazing example of so-called "design in nature" might prove as distressingly polyisomerous as the parts of a radial motor of an airplane.

The complexities of Aristotle's lantern seem to have been too much for even Nature herself to modify successfully, for so far as I can gather from the literature it is found only in the sea-urchins and holothurians.

Protochordates

Balanoglossus and the ascidians, derived, doubtless at different times, from the earliest echinoderm-chordate forerunners, are each highly specialized and in some respects degenerate but in different ways. While *Balanoglossus* is perhaps a protochordate masquerading under the habitus of a marine worm, the colonial sessile ascidians are protochordates almost transformed into the condition of corals or bryozoöns. But for all that, the *Balanoglossus* group seems to reveal its kinship on the one hand with the echinoderms through the *Tornaria* larva of its typical species and on the other hand with *Amphioxus* through the three-pouched larva of other species, while the ascidians retain their connection with *Amphioxus* through the mode of formation of their mesoderm, the expanded pharynx with its many gill-openings and the presence of a true notochord in the larval stage.

Each of the protochordates exhibits a high degree of polyisomerism in certain parts and in different ways. Thus in the adult *Balanoglossus* the numerous branchial organs are made up of elongate U-shaped

slits with little horizontal bars connecting adjacent U's. The details of the branchial apparatus differ in the four genera of balanoglossids (Delage and Hérouard, *Les Procordés*, Pl. IV and Fig. 34). The plates of Delage and Hérouard also illustrate the polyisomerism of the cells composing any given organ and we realize that macroscopic polyisomerism depends upon the homogeneity of the microscopic components. The *Tornaria* larva of *Balanoglossus* shows a highly polyisomerous arrangement of its ciliated bands.

Amphioxus.—Perhaps the highest degree of secondary intraorganic polyisomerism is attained in the fish-like *Amphioxus*, not only in its very numerous myomeres and gonads but in its multitude of tactile cirri, its greatly expanded pharynx and high number of gill-bars. The peculiar asymmetry of the developing gill-bars, as noted above, has been compared by Torsten Gislén with the asymmetry of certain fossil echinoderms (Fig. 7); but if the protochordates have indeed been derived from the carpoid echinoderms (see p. 280 above) the transformation has completely wiped out all traces in the adult *Amphioxus*; in this connection it will be realized that as the condition here called secondary polyisomerism advances it submerges the ancient anisomerous heritage of earlier ages.

The polyisomerous ciliated bands that form the endostyle in ascidians, in *Amphioxus* and in the larval lamprey perhaps date back to a period before any kind of jaws developed, when microscopic food was ingested by the action of cilia.

Ascidians.—The ascidians also supply us with examples of the principle that a primitive state of polyisomerism may give rise to a stage of anisomerism or differentiation and that this in turn may be replaced by a secondary polyisomerism. For example, it is not impossible that the simple tunicates (Fig. 9A) as an offshoot of the chordate stem and ultimately of the echinoderm stock, may represent a secondary return to a sessile mode of life. As a sessile animal such a typical simple ascidian is strongly anisomerous in its twisted digestive tract and localized gonads. But by breaking loose from its base (Fig. 9B) and budding in chains, a *Salpa* colony (Fig. 9C) as a whole has become secondarily polyisomerous.

Since polyisomerism may be either primary or secondary we can not hope to distinguish between the two merely by inspection of a given type without regard to the taxonomy and phylogeny of the group. Amateur students of evolution have often been misled by Herbert Spencer's classic concept of evolution as implying progress from homogeneity to heterogeneity, from simplicity to complexity. We now know from hundreds of well established instances that simplicity may often be the reverse of primitiveness and that progress, at least in the later chapters of evolution, has often been from a state of high local differentiation or anisomerism to the deceptively generalized-looking simplicity of secondary polyisomerism.

REDUPLICATION IN THE LOCOMOTOR SKELETON OF VERTEBRATES

The locomotor skeleton of vertebrates has evolved in relation to the arrangement of the zig-zag myomeres and to the septa between them. These myomeres are themselves products of lateral pouches from the primitive gut, so it is not surprising that they should be found in close functional connection with the median out-pocketing of the gut, which is the primitive notochord. But whereas the myotomes very early become polyisomerous, the notochord is unsegmented and continuous from the hypophysial sac to the tip of the tail. The notochord, composed of thin-walled

cells turgid with liquid contents and covered with an elastic sheath, affords the necessary resiliency and reaction against the rhythmic contractions of the myomeres.

served impressions of the posterior half of the body show an empty space in the midline beneath the longitudinal dorsal fin-fold and between the dorsal and ventral rows of small rod-like supports of the

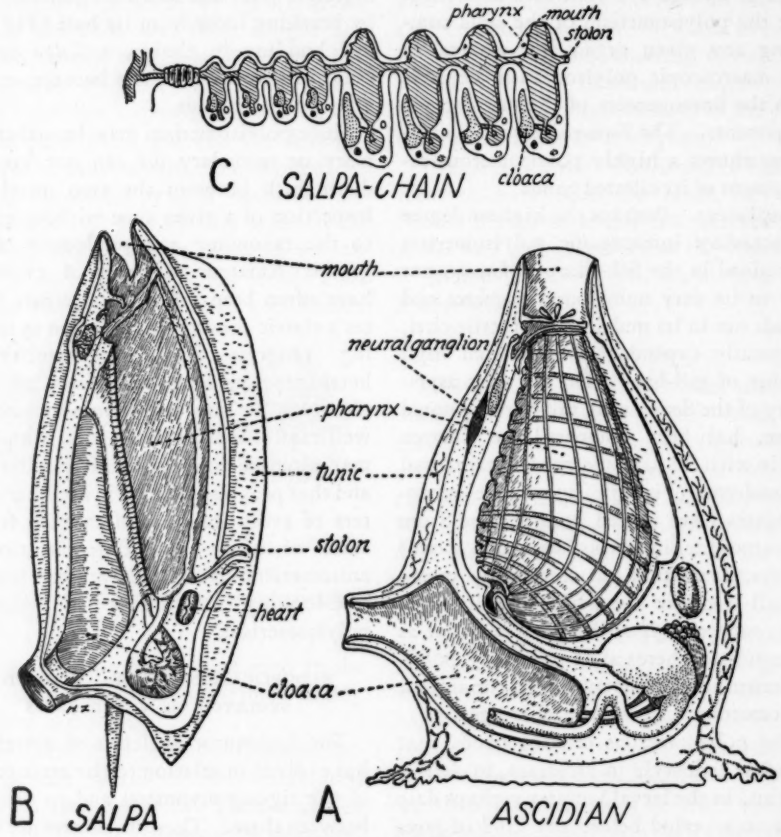

FIG. 9. ANISOMEROUS AND POLYISOMEROUS ASCIDIANS
After Delage and Hérouard

The primitive state of the notochord, as exhibited in *Amphioxus*, was doubtless also characteristic of the ostracoderms, in which there is a tube for the notochord behind the hypophysial fossa (Stensiö, 1927, Pl. 79). In another group of early chordates, the Antiarchi, several well pre-

caudal fin. These spaces can hardly have been filled by anything but the notochord.

In the elasmobranchs the thick outer or fibrous sheath of the notochord was invaded by skeletogenous cells which proceeded to lay down four pairs of blocks, two dorsal and two ventral, in each

sclerotome or primitive mesodermal segment. According to Gadow (1895), the anterior dorsal and ventral blocks were at the posterior end of one segment just in front of the intersection of the oblique septa of the myomeres with the elastic sheath of the notochord, while the posterior dorsal and ventral blocks were behind this septum and at the front end of the next segment. Goodrich (1930), however, dissents from this and holds that all four pairs belong within one segment. The two dorsal pairs (basidorsals and interdorsals) rest on the dorsal half of the elastic sheath and protect the spinal cord, while the two ventral pairs (basiventral and interventral) rest against the lower half of the fibrous sheath (Goodrich, 1930, p. 18). These vertebral blocks or arches not only protect the spinal cord and nerve exits but also serve as bases for the attachments of the myomeres. Those parts of the blocks that surround the notochord coalesce to form short cylindrical centra.

The vertebral centra of sharks exhibit a high degree of intersegmental polyisomerism as well as intrasegmental polyisomerism. Their diverse patterns, afforded by the deposition of calcareous material presumably along the zones and lines of greatest stress, are in general characteristic of the various groups of elasmobranchs and have been exhaustively treated in a great monograph by Hasse.

In the chimaeroids, which are highly specialized elasmobranchs, the central portion of the vertebral column attains a stage of secondary hyperpolyisomerism, as it is composed of a very large number of similar rings. In the embolomerous type of vertebrae, characteristic of the earliest known amphibians, each vertebra consists of two checker-like discs perforated by the notochord, the second one bearing the massive neural arch. The polyisomerous ribs, which function as lateral extensions of the vertebrae for the insertion of the lateral muscles of the myomeres, are movably articulated with the centra by two processes or heads, of which the lower or capitulum is articulated with the intercentrum; the upper or tuberculum articulates with the diapophysis of the neural arch (Watson, 1925). The neural arches articulate with each other by means of inclined paired facettes or zygapophyses, the function of which is to prevent strangulation of the spinal cord and spinal nerves during flexure of the body.

In the more ancient stegocephalian amphibians from the Lower Carboniferous there was also a high degree of primitive intersegmental polyisomerism from one end of the backbone to the other (Fig. 10). At the same time we see in these forms the beginning of regional anisomerism, since there is a rather rapid reduction of the ribs as we pass backward in the lumbar region to the sacrum and then a sudden marked increase in size of the two ribs that are expanded as a sacrum to receive the thrusts of the pelvic limbs transmitted through the pelvis. Again, behind the sacrum there is a rapid constriction of the intercostal diameter as the posterior ventral ribs, or haemopophyses, enclose only the postanal main blood-vessels.

At the other end of the vertebrate series in man, we find a high degree of regional anisomerism in the backbone, combined however with a considerable degree of intraregional secondary polyisomerism. Thus there is a sharp differentiation between the atlas and axis, between the seventh cervical and the first dorsal, between the last dorsal and the first lumbar, the last lumbar and the sacrum. In the postsacral vertebrae, especially where they are coalesced into the coccyx, the polyisomerism is partly secondary.

The great flying reptile *Pteranodon* ex-

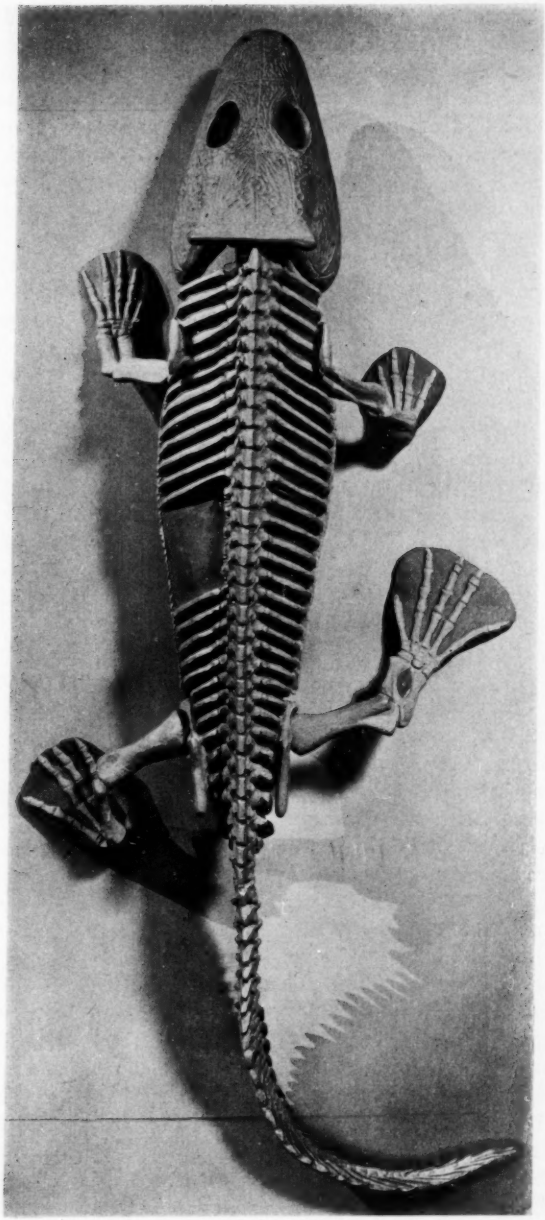

FIG. 10. MODEL OF AN EMBOLOMEROUS AMPHIBIAN, DIPLOVERTEBRON

Based on skeletons described by D. M. S. Watson. Showing primary polyisomerism and slight regional anisomerism in axial skeleton.

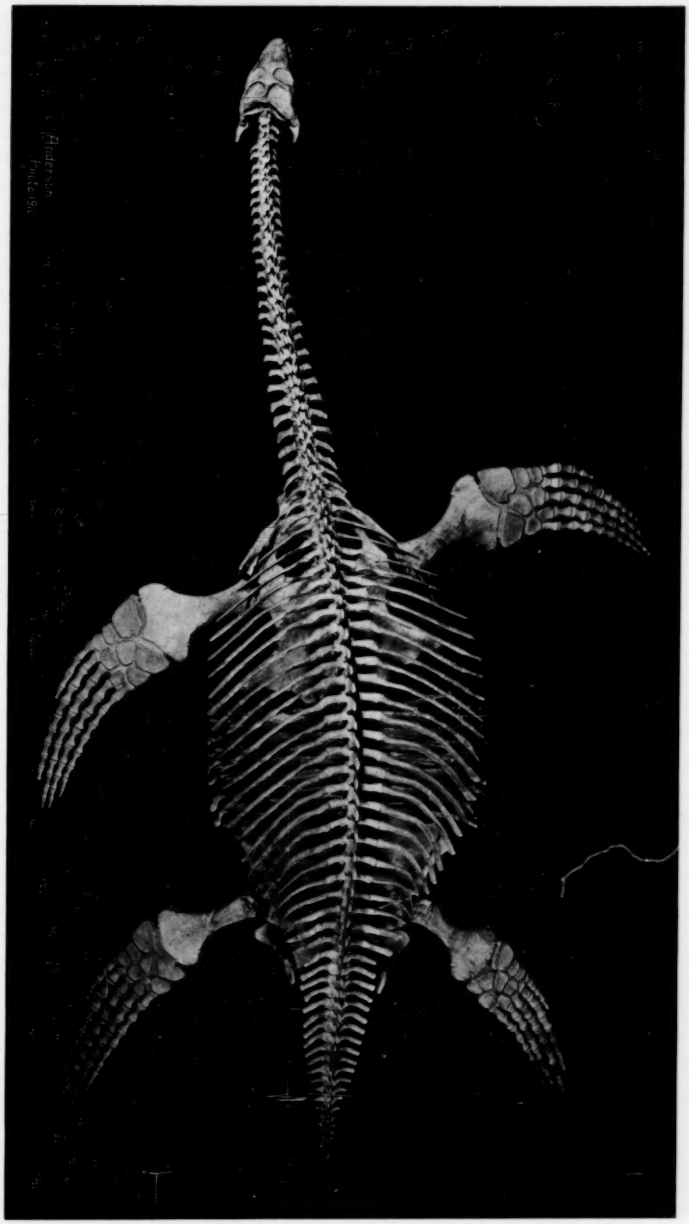

FIG. 11. SKELETON OF PLESIOSAUR, CRYPTOCLEIDUS OXONIENSIS

Mounted in the American Museum of Natural History by Charles Lang. Photograph by A. E. Anderson. Shows marked secondary polyisomerism tending to obscure an earlier anisomerism.

hibits a high degree of regional anisomerism in the backbone, for here a number of the anterior thoracic vertebrae are coalesced into a pseudo-sacrum to receive the thrusts of the enormous pectoral limbs, while many vertebrae in the sacral region are coalesced to form a synsacrum. Even here, however, there is also a considerable degree of intraregional polyisomerism.

Secondary polyisomerism in the backbone of vertebrates is quite common; for example, among fishes we have an extraordinary hyperpolyisomerism of the column in the morays and in other anguilliform fishes of several orders. Again in the class Amphibia many exhibit this feature in a high degree, especially among the early stegocephalians and Lepospondyli as well as in such urodeles as *Necturus*, *Siren*, and in the entire order of coecilians. The same principle ran riot among the reptiles, which produced many long-bodied, small-limbed and eventually limbless forms like the glass snakes and amphisbaenians among the lizards, as well as the true serpents.

Various phyla of extinct land-living reptiles gradually became aquatic and some of them even marine in habits. As they did so, the limbs were transformed into paddles and the backbone usually became de-differentiated and secondarily polyisomerous, so that in the ichthyosaurs, for example, the centra were simple and checker-like from one end of the column to the other, nearly all traces of the sacral differentiation being obliterated. Similarly the neural arches became alike and reduced their zygapophyses, thereby facilitating the free undulation of the backbone.

In the plesiosaurs there was also a rather high degree of partly secondary polyisomerism in the elements of both the axial and the appendicular parts of the skeleton (Fig. 11).

In many cases of excessive polyisomerism of the backbone (due apparently to a multiplication of the muscle segments) there is also a corresponding polyisomerism of the integument, frequently producing rings or a regular arrangement of spots. As a result of intrasegmental anisomerism combined with intersegmental polyisomerism, one or more elements of a pattern may be stressed at an early stage of development. Subsequent growth and elongation pull out these color patches into various component parts, so that we finally witness the beautiful color patterns of the pythons and vipers. The feathers of perhaps every species of birds would furnish many examples of inter- and intraregional polyisomerism and of the opposite tendency toward anisomerism but always with a specific or individual stamp of the resulting patterns. In the phenomenon called aquintocubitalism in birds, for example, which implies the presence of fifteen primary flight feathers on each wing, a great number of species, genera and even orders of birds exhibit a general polyisomerism of these feathers, combined with specific differences in the colors, patterns and forms of the overlying wing coverts.

The accessory locomotor organs, including the fins, paddles and finally limbs, likewise go through the stage of primitive polyisomerism and anisomerism, followed by either hyper-polyisomerism or hyper-anisomerism. Thus the pectoral and pelvic fins were once part of either continuous or nodally projecting paired finfolds, supported in the earliest fishes by spines or cartilaginous rods. These paired fins were originally of the same nature as the median fins and included rigid projections of the body-wall enclosing the segmental muscles and surmounted by crests of integument strengthened by rows of denticles coalesced into spines or fin-rays.

There was, however, one enduring rea-

son for anisomerism between the pectoral and the pelvic girdles, for the former was originally associated with the head and formed the boundary between the body musculature and the orobranchial chamber, while the pelvis was associated with the exit of the digestive and reproductive tubes and was thus situated on a node of the musculature between the flanks and the tail. Also the pectoral limbs, except among the pterosaurs, never acquired an attachment to the column, whereas the pelvic limbs by the upgrowth of the ilium gained a ligamentous contact with the girdle into anterior, dorsal and posterior elements. Such triradiate sutures in the case of fish skulls arise through the mutual pressure of three bony centers which are being pushed away from each other by their equal growth rates and by the reactions generated at their intersecting peripheries.

The distal ends of the paired fins were originally polyisomerous in so far as they were supported by serially arranged muscles and skeletal rods. By coalescence of some of these serial elements the base became constricted and the fin gradually

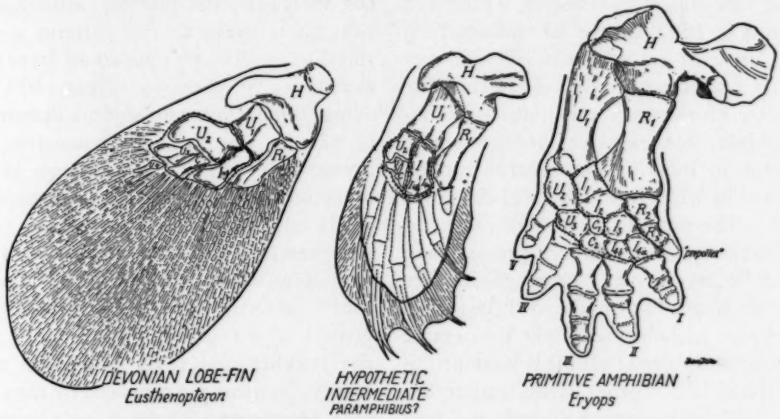

FIG. 12. SUPPOSED TRANSFORMATION OF PECTORAL PADDLE OF DEVONIAN LOBE-FIN INTO PRIMITIVE CHEIROPTERYGISM OF AMPHIBIAN, BY ANISOMERISM AND SECONDARY POLYISOMERISM

sacral ribs, thus indirectly transmitting their thrusts to the column. The marked and persistent anisomerism of the pectoral and pelvic girdles is thus readily understandable in the light of the functional history of these elements. Nevertheless, a secondary tendency toward polyisomerism very early asserted itself, in that, especially among the Permian reptiles, each half of both pectoral and pelvic girdles came to acquire a triradiate suture centering respectively in the glenoid and acetabular depressions and dividing each

changed into a paddle with a movable wrist-like base. In the fan-like paddles of the early crossopterygians (Fig. 12) one set of rods (H, U_1, U_2, U_3, U_4) became the functional axis and one member (H) of this set gave rise to the humerus or single proximal piece. When the paddle was bent sharply upon itself in pushing the body on the mud, anisomerous increase of the proximal elements took place together with some secondary polyisomerism in the elements that were to become the carpals. A similar history in the pel-

vic limb resulted in the anisomerous proximal elements and the polyisomerous extremities.

In the earliest tetrapods each of the elements of the primitive hind foot has the somewhat deceptive appearance of complete homology with the corresponding piece of the fore foot; but it is more than likely that this is largely due to intersegmental polyisomerism.

An even more complete homodynamism and polyisomerism is developed secondarily between the pectoral and pelvic paddles of typical plesiosaurs (Fig. 11).

The fore and hind limbs of birds have attained a high degree of anisomerism with little or no tendency toward secondary or tertiary polyisomerism. The skeleton of the pectoral limbs of humming-birds, for example, is excessively different in function, in general appearance and in detail from that of their pelvic limbs. The same is even more conspicuous in the penguins, where pectoral and pelvic limbs are used, although in very different ways, in propulsion through the water and on land. And yet the remote common ancestors of all birds were primitive lizard-like reptiles with similar but secondarily polyisomerous hands and feet. This case suggests that marked regional anisomerism between serially homologous parts is concomitant with equal differences in function and at present I can think of no exceptions to this rule.

CONCLUSIONS

The phenomenon of polyisomerism, whereby adjacent or serially homologous parts of the body are moulded into similar patterns, obviously results from the interaction of many forces, influences and conditions such as the following: the production of similar units of building material by the digestive system, the similar influences upon a row of homologous parts exerted by serially homologous nerves and blood-vessels, the similar effects upon all the units of the series by specific endocrine products, in stimulating or retarding growth or in changing the physical or chemical properties of any of the component tissues; finally we have to reckon with the similarities that were initiated by forces let loose by the unfolding genes.

In short, "wholeness," "specificity" and "aristogenesis" seem to be names for certain aspects of the behavior of living kaleidoscopes that slowly evolve through the ages: the little pieces ("aristogenes") that go to make up the patterns are the small units that are budded off from some rhythmically growing organ like the dental lamina; the patterns are determined in part by the primary symmetries and asymmetries of the fertilized egg, in part by secondary symmetries and asymmetries produced, for example, by the recurrent invagination of the ectoderm and the mesoderm so as to form dental caps and tooth germs; or by nodal retardation of growth in a rapidly growing strip, as in the notches and folds of rodent teeth; finally, patterns are produced by the recurrent interference between polyisomerism and its opposite, anisomerism.

As to the occasional recurrent alternation of polyisomerism and anisomerism, let us consider the long line of vertebrates that culminated in the existing narwhal. In the remote reptilian ancestors of the mammals the dentition was at first strongly polyisomerous; this we may call primary polyisomerism. In the higher cynodonts this condition began to give way to a moderate degree of anisomerism, which was progressive up to the time of the earliest creodonts; this may be called the first cycle of anisomerism. In the ancestors of the hyaenodonts the dentition as a whole was anisomerous but the upper

molars were becoming secondarily polyisomerous, through the emphasis of their metastyle shears and the reduction of their protocones. Traces of this condition are still visible in the earliest archæocetes, but by the time we reach the squalodonts the teeth have begun to multiply and to be much simplified and polyisomerous, a tendency which culminates in the dolphins. Here is the phase of secondary polyisomerism. In the immediate ancestors of the narwhal one pair of these similar teeth began to enlarge; this movement culminated in the excessively anisomerous stage of the narwhal, which has in the adult but a single tooth left in the form of a huge spirally wound straight tusk. Thus we have secondary anisomerism of an extreme type. The next stage would probably be loss of all teeth (negative anisomerism).

The usefulness of polyisomerism or reduplication is that it has enabled the same function to be performed by many different units, so that the necessary work could be distributed among many; thus a massive result could be achieved by mass action of small units multiplied by time. As an example we may cite the amazing achievement of the minute teeth of the radula of certain gastropods in boring through the thickest part of the shell of a clam, or the powerful mass action of the tube-feet of a starfish in pulling open the shell of an oyster.

On the other hand, anisomerism, or the inequalization of parts, resulting from the overgrowth of one part of a polyisomerous series, has proved useful under the following conditions: (a) when the enlarged anisomerous parts have been compelled to bear the brunt of attack, as in the canine teeth of the sabre-tooth tiger, or when they serve as a shield, as in the plates of the carapace of the tortoises; (b) when the enlarged parts serve as a fulcrum, anchor or stay for adjacent parts, as in the coalesced anterior cervical vertebrae that support the immense head shield of ceratopsian dinosaurs, or as in the enlarged sacral ribs that receive the thrusts from the pelvic limbs; (c) when adjacent pieces of an originally polyisomerous series perform narrowly delimited parts of some complex function, as in the several parts of the atlas-axis complex of man.

Thus the presence of polyisomerous parts implies mass action, the presence of anisomerism implies inequality of stresses, highly differentiated functions.

In all Metazoa polyisomerism, or the formation of numerous small unit organs of the same type, is the next step above cell division and the differentiation of the primary germ layers. The quality of specificity or individuality becomes manifest in each case of polyisomerism at earlier or later stages of ontogeny. Polyisomerism, either as between organs or as between the smaller units that compose them, is a universal property of living things; it is the specificity of the polyisomerism that remains to be explained. Here from a historical point of view we emphasize the divergent, cumulative compound-interest-bearing effect of an infinite number of small conditioning factors operating on divergent hereditary lines through geologic time.

In general the nature of protoplasm is such that a separated part tends to assume the form of the parent mass, hence polyisomerism is a result of an inherent property of protoplasm. On the other hand, anisomerism, or hereditary divergence, arises when the forces of polyisomerism are unevenly distributed so that one part grows or evolves faster than its neighbors.

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SIGNIFICANCE OF THE BIOTIC COMMUNITY IN ECOLOGICAL STUDIES

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INTRODUCTION

DURING the eighteenth and nineteenth centuries, many leading biologists sought a knowledge of nature in the open. These were the days of famous naturalists, systematists, and faunal and floral geographers. Toward the end of the nineteenth century a group of gifted laboratory workers came to occupy the center of the stage, and the emphasis on field work unfortunately lessened somewhat. In these days of the twentieth century a renewed interest in Nature out-of-doors is evident. The proponents of "scientific natural history," or ecology, are making ever more valuable contributions. Their work is commending itself increasingly to the general biological public, and their numbers and influence are steadily augmenting. A few praiseworthy efforts have been made, also, toward the coördination of field and laboratory investigations.

Ecologists, like other biologists, have usually entered their chosen field through specialized work either on animals or plants. As studies proceed of the structure and relationships of *communities* of living organisms in the field, more and more workers are appreciating the vital character of the interdependencies between plants and animals. It is being realized that investigations of "animal" ecology and of "plant" ecology assume their proper status only in the great coördinating field of bio-ecology (or simply, ecology), the study of all living organisms, plant and animal, as related to their environment.

THE BIOTIC COMMUNITY AND THE ECOLOGISTS

Seemingly the trend among ecologists is increasingly toward the bio-ecological point of view. In an outstanding paper which summarizes the situation, Phillips (1931) presents a résumé of the principal divergent views regarding the relations of plants and animals in natural communities. Phillips points out that by one group of workers, including most plant ecologists, animals are regarded as biotic factors external to the plant community. By another group, including many animal ecologists, plants are regarded as a portion of the habitats in which the animal communities live. By a third group, of which Phillips himself is a distinguished representative, plants and animals are viewed as interrelated, co-acting constituents of an integrated biotic community.

Under the first group, including ecologists who regard animals as biotic factors external to the plant community, Phillips discusses the work of Warming, Flahaut and Schröter, Tansley, Yapp, Farrow, Watt and Osborn. As representing the smaller group of animal ecologists who believe that plants should be considered as a portion of the habitat, i.e., not as members of the community, Phillips suggests Klugh, Pearse, Chapman, Elton and Adams.

We next consider those who regard plants and animals as interrelated, co-acting constituents of an integrated biotic community. Möbius, who in 1877 sug-

gested the terms *Biocönose* or *Lebensgemeinschaft*, is cited as a pioneer in the concept that plants and animals together may form a biotic community in possession of a certain definite territory.

In his discerning investigations of the lake as a microcosm, Forbes (1887, p. 77) referred to the sensibility of the organic complex in the lake. He pointed out that whatever affects any species belonging to this complex must speedily have its influence on the whole assemblage. It is impossible, he said, to study any form completely, out of relation to the other forms. It is necessary to make a comprehensive survey of the whole before one can acquire a satisfactory understanding of any part. Forbes was interested in studying the natural interactions by which the mere collocation of plants and animals has been organized as a settled and prosperous community, as he put it. The concept of the biotic community was clearly in his mind, though he gave it no name.

Merriam (1890, p. 27) called pointed attention to the coincidence in the limitation of the life areas or zones on San Francisco Mountain. In a later paper (1892, pp. 7–8) he gave a list of fifty-six authors who have proposed faunal and floral regions or zones for North America. Of the fifty-six, but one—Dr. Merriam himself—based his proposed bio-geographical divisions on both animals and plants.

The point of view of the botanists who had gone farthest along the road toward bio-ecology, was expressed by Clements (1905, p. 16) who noted that animal formations, although often poorly defined, do exist, and frequently coincide with plant formations. In his *Plant Indicators* (1920, p. 38) Clements referred to the growing recognition of the community as consisting of both plants and animals.

Vestal (1913, p. 13; 1914, p. 444) gave still clearer recognition to the general proposition that the animals and plants in a given terrestrial environment are intimately related.

In 1915 (p. 20) Shelford, discussing the principles and problems of ecology as illustrated by animals, noted that agreement between animal communities and plant communities is evidently the rule.

The same year Adams (1915, p. 157) referred to the vast number of smaller animal, or biotic communities in the forest, but seems to have had in mind animals only in his thought of the biotic community.

Both Yapp (1922, p. 11) and Tansley (1923, p. 166) have written of the grouping of plants and animals together into communities. But in 1929 (p. 680) Tansley believed it essential to consider the plant communities separately, and to regard animal factors as external to them.

During the last fifteen years, the concept of the biotic community as an integrated unit assemblage made up of both plant and animal constituents has been growing apace. We cannot stop to examine all the evidence and opinion; but we wish to point out the views of a few more of the active workers in the field to indicate the direction of the trend.

Clements has proposed the term *biome* to embrace both plants and animals in a common community of living things. We thus have the terms *vegetation* or *flora*, standing for the plants; *fauna* or "*animal life*" for animals; and *biome*, a short and appropriate name for the biotic community embracing both plants and animals.

Beginning about 1918, a group of workers, largely in the western and southwestern United States, have been giving special attention to the bio-ecology of the grassland formation and desert, with special reference to insects, birds, and

rodents. Reference to some of these studies has been made by Clements and Taylor (1923).

In 1925 (p. 21) Weese expressed the opinion that "The animal communities of a given region cannot be considered, logically, separately from the plant communities."

Studies of birds, mammals, and plants in many places in the west, as related to farm, forest, and grazing ranges, have unmistakably indicated the interdependence of plants and animals. Relatively thorough studies have been made in plant ecology, but adequate provision for work on animals has not been made. In 1925 (pp. 390–393) the present writer noted the lack of attention to zooecology, pointing out that the problems of culture, maintenance and administration of agriculture in general, and forage and forest in particular, directly involve animals as well as plants. In a later paper (1927, p. 281) he expressed the opinion that a thoroughgoing conception of the bio-ecological nature of forest problems, of grazing problems, and of most other agricultural problems would lead to more certain and satisfactory solutions.

In 1926 Phillips emphasized the important interrelations between animals and plants, especially as shown by the services of animals in dispersing the fruits and seeds of forest species. In 1931 (p. 14) he wrote:

> Throughout the . . . account I have given of the inter-relations of plants and animals in the Knysna forests, runs the golden theme that the whole community of life is a beautifully integrated series of factors, responses, reactions, and co-actions. To remove the animals would result probably in dire results for the plants, to fail to include them in the concept of the community cuts across logic.

Allee (1926, pp. 462–467), in his discussion of the distribution of animals in a tropical rain-forest, evidently assumed the existence of biotic communities. In another place, discussing needed lines of investigation in American entomology, Allee (1927, p. 439) referred to insect communities as abstractions, pointing out that really there are only biotic communities, i.e., groups of plants and animals which are more or less closely integrated into a community system. Still more recently Allee (1934) has used the term geo-bio-ecology, to indicate the complex relations of living things with each other and with their non-living environment.

In his comparison of the animal communities of coniferous and deciduous forests, Blake (1926, p. 90) assumed the interrelationship of plant and animal life.

Cooper (1926, p. 396) expressed the opinion that the strictly logical procedure would be to include the animal life with the vegetation in our communities.

In a clear-headed review of Pearse's *Animal Ecology*, Jones (1926, p. 504) expressed the view that the classification that ecologists must eventually settle upon will be one in which both plants and animals are included in the same communities.

THE BACKGROUND OF THE BIOTIC COMMUNITY

Like the individual plant or animal, the biotic community is the product of environment (See Breazeale, 1927, pp. 404–405). The organized assemblage of species must be adapted to its surroundings or it would not be here. The interdependencies between plants and animals are as much the products of adaptation as are the relations between the individual and its inorganic environment.

The assumption that "plant" life appeared first on earth, being followed later by animal life, requires modification. Little is known about the primal forms, but present-day observation and experience support the hypothesis that plant-like and

animal-like forms have existed together as long as life has been in the world. The earliest organisms may well have combined plant and animal characteristics. Haeckel years ago (1904, p. 205) placed the most primitive living things in the protist kingdom. There are several simple creatures still in existence that are difficult to classify as belonging to either the plant or animal kingdoms.

If we are to make our assumptions on the basis of observation, experience, and experiment, must we not conclude that the biotic community reaches far back in time; that the protists may perhaps be regarded as individuals partaking somewhat of the characteristics of both plants and animals; that as the plant and animal kingdoms diverged their members, respectively, lived in close association, and were interdependent? These formed the earliest true biotic communities.

THE BIOTIC COMMUNITY MAY BE COMPARED TO AN ORGANISM

When the manifest and inevitable interdependencies between plants and animals are considered it is increasingly clear that it is the *biotic community*, and neither the animal community alone, nor the plant community by itself, that is the real entity. More than fifty years ago Semper (1881, pp. 29, 32–33) likened the animal community to an organism. It is well known that Clements (1905, p. 199) referred to the plant formation as an organism.

That the individual organism and its environment may be regarded as the internal and external portions of a single system of material and energy was recently asserted by Livingston (1929, p. 1107). Even more accurately, it seems to the present writer, the *biotic community* and its environment may be regarded as the internal and external portions of a single system of material and energy.

One of the outstanding features of the Matamek conference on biological cycles, according to Huntington (1931, p. 234) was the frequency with which one member or another emphasized the fact that in spite of minor differences, the general reactions of man, animals, and plants are essentially the same. Why not? All are parts of a great biotic community.

Brehmer (1927, pp. 247–250) concluded that the individual organism is a vast community in a high state of coöperative activity. In the biotic community we recognize a still vaster community than that of any individual animal or plant, and indeed, embracing all animals and plants in a particular place. Like the individual, the biotic community is also in a high state of coöperative activity.

There are three important ways to test the thesis: That the biotic community rather than the animal community alone, or the plant community alone, is the true unit, corresponding in its development to a complex organism.

(1) Trace the interrelationships between the component plant and animal species of the biotic community. If the interrelationships are vital rather than incidental our thesis will be maintained.

(2) Note what happens when a single species of plant or animal is disturbed or eliminated. If such disturbance affects only the species involved, or, if a plant, only other plants, or, if an animal, only other animals, our thesis will be militated against. If, on the other hand, far-reaching effects permeate the entire community, influencing many plants and animals, it will be upheld.

(3) Study the results following introduction of a foreign species of plant or animal. Are only plants affected by the introduction of a foreign plant, and only animals by the bringing in of a foreign animal, or is the entire biota influenced?

We scarcely need to do more than state these questions before the answers are apparent.

(1) The interrelationships between the members, plants and animals, of a biotic community are vital, not incidental. Selected examples are given in a later section of this paper under the heading "Some Interdependencies between Plants and Animals."

(2) Disturbance of a single important species of plant or animal is likely to have far-reaching effects on many or all other plants and animals. Cut a forest and plants and animals generally, from the highest inhabited forest stratum to the lowest depths of the forest soil where organisms occur, are undoubtedly affected. The entire original biotic community is shaken to its foundations and, to a great extent, eliminated and replaced. Succession begins anew.

Overgraze a stock range and similar far-reaching results may ensue. The climax grasses tend to disappear, and various less valuable species become conspicuous. The surface of the ground is less well protected, and erosion and run-off are accelerated. The animal inhabitants, from insects to rodents, tend to be altered.

Release of an overgrazed range from ultra heavy pressure exercises like profound effects, whether the pressure has come from domestic livestock or native grazing species like the buffalo. Many forms of vegetation previously suppressed are now released, and as they change, so do many of the insects, birds, and mammals. Our studies show that these changes may be of considerable significance.

Tansley (1923, p. 169) has pointed out that there is abundant evidence that the destruction of carnivorous birds (hawks, jays, etc.) and small animals (stoats, weasels, etc.) by game keepers in England, handicaps or destroys the chances of tree reproduction in many English forests.

But elimination of important plants or animals is not the only kind of modification that exercises far-reaching effects on a biota. Abnormal increases in the numbers of particular species may have an influence also. As Hermann Krauch (U. S. Forest Service) pointed out to the writer, these abnormal increases themselves are due to a disturbance of controlling factors. The plagues that occurred at intervals in Egypt, and from which at some time or other few countries have been free, are notorious in their influence on the entire biotic community. Abnormal increase of the deer on the Kaibab National Forest in northern Arizona threatened the very existence of important elements of their forest habitat.

(3) It is clear to the most superficial observer that introduction of exotic species, whether of plants or animals, may have far-reaching effects on the entire biota.

Some of the introductions in America we number among our most serious pests. Consider the numerous pestiferous weeds, the boll weevil in the United States; the blister rust, the corn borer, the Norway rat, all introduced species, and all extremely serious economically, affecting the status of many plants and animals, including man. The prickly pear in Australia, the rabbit in England and Australia, the Colorado potato beetle in Europe, the American gray squirrel in England, the American muskrat in England and in western Europe, the mongoose in Jamaica, come to mind as additional examples. Perhaps the chief difficulty in connection with introductions of this character is that the natural controls are not introduced along with the troublesome

species, or that the total environment in the new area simply does not suffice to keep the newcomers in their place.

Agriculture, with its beneficial introductions, as of the potato and numerous grains, fruits, and vegetables, and of domestic animals, has almost completely altered the natural biota over large areas.

It is perhaps obvious without going into further detail, that introductions of foreign plants have had a far-reaching influence on both plants and animals; and that the introductions of animals have had similarly comprehensive consequences. In many instances the effects of introductions of plants apparently have been more profoundly registered on animals than on plants; and the effects of introduction of some foreign animal have perhaps shown up more conspicuously among the plants than the animals of the region where it was introduced.

There is a question, in the mind of the writer, how far we are justified in applying the concept "individual." The individual organism is sometimes thought of as one capable of independent existence. But few or no organisms are capable of independent existence. They depend utterly, in final analysis, on other individuals or species. Certain termites perish in the absence of their symbiont protozoa. Animals would quickly disappear were it not for the plants on which they feed. Apparently there is little rugged individualism in nature. Plant associations or animal associations are abstractions, important but incomplete. Apparently the biotic community, the interacting, interrelated, interdependent, loosely or closely organized cooperative commonwealth of plants and animals in their environment, is more nearly an individual organism than any of its parts. Seemingly, the relations between organisms, and between the organisms and their surroundings, are so close and obligatory that the organic-inorganic complex complete is the real unit.

THE BIOTIC COMMUNITY—SOMETHING MORE THAN THE SUM OF ITS COMPONENTS?

It is a commonplace that a chemical element, such as hydrogen, when isolated, possesses certain properties. When combined with oxygen to form water, however, the situation is seemingly quite different. The compound has characteristics one would never suspect from a study of its elements.

In much the same way an individual organism or a single species possesses certain characteristics; but when joined with its fellows in a biotic community other qualities, often completely unsuspected, emerge. As a matter of fact, as Wheeler (1928, p. 38) has pointed out, there is something fundamentally social in all organisms, and all organisms are at least implicated in some biocenose, or, as we would say, biotic community. There is no such thing as a hermit organism.

We can never learn all we need to know about living things by a study of individuals or even of species. Knowledge of the relations in which species stand to each other, information regarding their organization into biotic communities, are essential to an adequate understanding of nature.

SOME INTERDEPENDENCIES BETWEEN PLANTS AND ANIMALS

The juniper in parts of the Southwestern United States is apparently dependent for its distribution to a considerable degree on the sheep. (Information on sheep-juniper relations furnished by C. K. Cooperrider, U. S. Forest Service.) The seeds of the juniper pass through the sheep and are distributed in areas previously not occupied (recently at least) by the juniper. The sheep also tend to weaken the grassy and herbaceous growth of the region, thus lessening its ability to compete with the juniper, and paving the way for the establishment of the aspiring juniper seedling.

On the Santa Rita Experimental Range, near Tucson, Arizona, as on all grassy range country, the destiny of the herds of livestock is dependent on the welfare of

the grasses on which they principally feed. The grasses in turn, depend for their own future status on the livestock. If stocking is too heavy, the climax perennial grama grasses are replaced by the annual "sixweeks" gramas and needle grasses, as well as a variety of weeds. Even the native rodents (especially the jack rabbits and banner-tailed kangaroo rats) are concerned here. Where, as a result of over-grazing, the vegetation is having a struggle to maintain itself, rodents alone may be sufficiently influential to turn the tide back from the more palatable and valuable climax stages to the relatively worthless secondary stages of vegetation.

On an overgrazed range on the Wichita National Game Preserve, Weese found certain insects many times as numerous as in the climax stage of vegetation. Rodents are notably more numerous in the mesa and semi-desert types on the Santa Rita Experimental Range than in the better-grassed foothill types. There is accumulating evidence that certain rodents and insects may sometimes be both a cause and an effect of over-grazing. A cause, for where they are numerous they do cut down the vegetation, and tend to accentuate the overgrazed condition, especially during periods of extreme drought. An effect, for where, for any reason, overgrazing has developed, and the secondary herbs and grasses come in, certain insects and rodents also tend to increase.

Reference has already been made to the effects of forest removal. Where a forest is clearcut, and thereby the dominant species of plants (the timber) removed, there obviously follows a profound change affecting every other plant and animal in the area, as well as the physical and chemical factors of the site. Even the microclimates of the soil and the surface strata of atmosphere are modified.

In parts of Africa man may be affected by the highly fatal disease, sleeping sickness, the germ of which, a protozoan, is transmitted by an insect, the tsetse fly. But this is not the whole story. The tsetse fly is abundant where there is "bush" or forest; in fact, clearing the vegetation around the native villages is receiving attention as a control measure. Phillips (1930, pp. 217–219) gives an account of a deciduous scrub, of which the genera *Grewia*, *Pseudoprosopis*, *Bussea* and other plants are members. This scrub community harbors few game animals and appears to form a barrier to the advance of the tsetse. The chain of causes and effects in relation to sleeping sickness again cuts across the bounds of the plant and animal associations and is clearly seen to be bioecologic in its nature.

Darwin (1898, p. 66) has pointed out that the dependency of one organic being on another lies generally between things remote in the scale of nature. This generalization is illustrated in every biotic community and is a strong argument for the naturalness and validity of the biotic community concept. The flowering plant depends on the bee. Growing vegetation depends on the soil organisms, probably always including animals, which keep the complex structure of the soil in suitable condition for the support of vegetation. The deer depends on the browse plants of its habitat. The bark beetle depends on its forest tree host. The mourning dove requires the seeds produced by numerous herbs. The carnivores depend on the herbivores, which themselves depend on a variety of plants, which, frequently or nearly always, depend on soil animals, and so on in a great physical-chemical-biotic circle of relationships. Man himself, in his food and shelter requirements, illustrates a hundred times a day his

dependence on things remote from him in the scale of nature, mostly plants.

FUNDAMENTAL INTERDEPENDENCIES BETWEEN ANIMALS AND PLANTS ARE USUALLY MORE OBLIGATORY AND INEVITABLE THAN THOSE BETWEEN PLANTS ALONE OR BETWEEN ANIMALS ALONE

Although in numerous instances insects are parasitic on animals, and predatory animals dependent on plant-feeding creatures, nevertheless many or most animals are obviously more dependent on certain *plants* of their environment than they are on any other animals, for food, or for shelter, or both. It is just as obvious that many plants are more dependent on certain animals than they are on any other plants. We have only to recall the dependence of the flowering plant on the bee or moth or bird, which cross-pollinates it, to see how the matter works out in a considerable number of cases. Pickens (1929) has recently shown that in California the white sage (*Ramona polystachya*), which is pollinated by a large bee (*Xylocopa*), nevertheless occurs in some localities where this species of bee is absent. In such localities, the Costa hummingbird (*Calypte costa*) functions in the transfer of the pollen.

The relation of the *Pronuba* moth to the Spanish bayonet (Genus *Yucca*) of the Southwestern deserts has been made known by Riley and his associates (see Folsom, 1922, p. 222). Jepson (1910, pp. 169–170) has summarized the situation as follows: The flowers are incapable of self-pollination. Each species of *Yucca* is dependent on a particular species of moth.

"The female *Pronuba* works by night, collecting the pollen from the anthers and rolling it into a little ball; she then flies to the flower of another plant, desposits her egg in the ovary, and then in a manner which seems to indicate that her actions are full of purpose and deliberation climbs to the style and thrusts the pollen ball far down the stigmatic tube. The larva destroys about a dozen seeds, but even if several larvae develop, many perfect seeds are left."

Literally thousands of plant-animal relationships, as obligatory as the examples given, are well known to science.

A plant attacked by certain insect pests is or may be vitally dependent on parasitic enemies of the pests and on insectivorous reptiles, mammals, and birds.

An instance of interdependence is that of the carnivorous plants, including the sundew (*Drosera*) and its associates in the Droseraceae (also *Pinguicula* and *Nepenthes*), which capture, digest and absorb animal matter; and *Utricularia* and its close allies, which, while they cannot digest animal matter, nevertheless absorb the products of decay of the animals they capture. For a full discussion of these species, consult Darwin (1889).

The citrus industry in southern California is to a large degree dependent on a certain lady-bird for its very existence, for the cottony cushion scale, otherwise, would limit or perhaps wipe out the oranges, lemons, and grapefruit. The lady-bird is so effective an enemy of the scale, however, that the ravages of the latter are negligible.

Another California industry of large proportions, namely, the culture of the Smyrna fig, is dependent on a plant-animal relationship. The superior flavor of the Smyrna fig, explains Folsom (1922, p. 428), results from the presence of the ripe seeds which result from fertilization. This process is accomplished by a tiny fly of the genus *Blastophaga*, which develops in the gall-like flowers of the wild fig. The winged female, emerging from the gall covered with pollen, enters the young flowers of the Smyrna fig to lay its eggs, and in the process pollenizes them.

The welfare of plants is closely related to soil conditions, and soil conditions are intimately linked up with the number of

earthworms, burrowing rodents, ants, and other soil forms, large, small, and smaller.

Many plants are more or less dependent on fruit and seed-eating species of animals for planting their seeds, and particularly for the extension of their ranges.

Plants in general are somewhat dependent on animals for the very carbon dioxide which they require for their photosynthetic processes, although this relationshp is doubtless of slight importance.

Willis (1922, p. 203) referred to animals as a function of plants, indicating his appreciation of the intimate interrelationships of the two kingdoms.

Obviously all the herbivorous animals are dependent on their food plants, probably more closely, in at least the vast majority of cases, than on any other animals. Animals requiring certain plants for shelter are also more dependent on such species of a different kingdom than on any other animals. Even carnivorous animals are indirectly dependent on plants.

There would be no need to labor a point that is a biological commonplace were it not that much biological work, involving both theory and practice, has been done on the theory that plants and plant communities are separate and independent from animals and animal communities.

GRADES OF BIOTIC COMMUNITIES

Biotic communities may be graded, according to their size and complexity. One may give attention to the biotic community in a fence-post, or in the intestine of a cat, or under a stone in a running stream, or in an ant mound, or in the nest of a mouse or a bird.

Some of the lesser biotic communities are of surpassing interest. Take the communities in such places as the dens of the banner-tailed kangaroo rat in the arid Southwestern United States. These dens are the world of action for a number of insects and soil organisms, a refuge and shelter for several reptiles and even mammals. Organisms are relatively abundant in the worked earth of the kangaroo-rat den, while relatively rare outside. A number of animals habitually and characteristically use and take refuge in the dens. This is true of certain snakes, especially gopher snakes and racers. It is also true of Gila monsters, and a number of other lizards, including the delicate banded gecko (*Coleonyx variegatus*). There is thus a rich community represented in these dens, including members of widely diverse animal groups, as well as doubtless many bacteria and other plants. All depend for food on their animal confrères, or on the accessible vegetation or animal life within or in the neighborhood of the den, or on decomposition products from some of these other sources.

On the other hand one may enlarge his view and regard the biotic community of a particular stream-side or pasture, or pond, or bay, or field border, or wood lot. Or he may still further expand his vision to embrace the biotic community of some vast forested area, or extended grazing range, or a particular life-zone, region, or realm, or say, of a continent or the ocean itself. Biotic communities vary in size and complexity from the circumscribed assemblages in closely restricted habitats to the largest biotic community, comprising all living forms on earth.

Conceived in this manner, one should have no particular difficulty with the problem of wide-ranging forms of animals, as the mountain lion (*Felis concolor* and related forms), badger (*Taxidea taxus*), and others, which occur rather indifferently in the hot, low country along the Rio Grande and Lower Colorado River, and in the cold zones of the Sierra Nevada of California and the Mogollons of Arizona and New Mexico. These mammals and a number of plants also, occur as members of a more extended and extensive biotic community than the others. Longstaff (1932), after an ecological reconnoissance in West Greenland, wrote: "It is striking how little the animals fall into definite communities and

how few habitats have exclusive species." The wide-ranging species are ecologically adaptable. We must fit our biotic communities to the organisms composing them, and not the other way around!

Man himself is a significant example of a wide-ranging form. One way or another, by carrying special equipment for securing necessary food and shelter, he is able to adapt himself to a wider range of environments than any other creature. He is at present the most prominent and in many respects the most powerful member of the world biotic community. His risks, opportunities, and responsibilities are correspondingly great.

It is probably true that no biotic communities in the world are "closed" in the sense that they are completely cut off one from another. Life exists in the similitude of a vast interrelated network, terrestrial and subterranean, aerial and aquatic. Any biotic community which is less than the world community is at most an incomplete and somewhat artificial thing, with arbitrary lines drawn for convenience in treatment. Ecology, in usually dealing arbitrarily with its material for study, is like every other science. All we can do, with our finite capacities, is to investigate and explore as best we may the tiny corner of the universe to which we have immediate access. But our arbitrary divisions should not blind us to the essential unity of all nature.

ANNUAL AND SEASONAL VARIATIONS IN THE MAKEUP OF BIOTIC COMMUNITIES

The species composition of the biotic community, especially on the animal side, is variable according to the season of the year. (Phenomena of biotic succession are of course not here discussed.) At one season, for example, a host of migratory birds, or perhaps of insects, may quite markedly alter the aspect of the community in any given place. While it is quite proper to include wide-ranging and migratory forms in the communities where they are found at any time of year, the basic structure of the biotic community is probably builded chiefly by the species that breed or reside permanently therein. Thus the western robin (*Turdus migratorius propinquus*) may be a member of the biotic community of willow-bordered bottoms at Tucson, Arizona, in winter, though its ecologic importance may not be very great there. It is a much more important member of the streamside subdivision of the yellow pine biotic community of the nearby Santa Catalina Mountains in summer. For there it is a breeding bird. It is true that in regions like the Gulf coast, where migrant birds concentrate in great numbers in winter, these non-breeders may as it were set the pace for the biotic community the year through. In general, however, the resident or breeding substratum of animals and plants is of fundamental significance.

The influx at certain seasons of the year of wide-ranging or migratory birds or mammals is somewhat analogous to seasonal aspects which we observe in the flora.

Plants avoid or escape unfavorable seasons by becoming quiescent, either as seeds, spores, bulbs or other underground parts, or sometimes as resting stages both above and below ground. Some animals, as insects, amphibians, reptiles, and hibernating mammals also avoid inimical conditions by becoming quiescent. Most warm-blooded species cannot do this, but must migrate. From our standpoint, therefore, the processes are strictly analogous, as both aim to secure the same thing, namely, survival in a particular geographic area where otherwise survival would be impossible.

In the southern Arizona region, there are no less than 122 annual plants that appear above ground only in winter (Thornber, 1909, p. 104). Among these are such forms as *Amsinckia intermedia*,

Erodium texanum, *Gilia* (several species), *Lupinus leptophyllus*, *Mentzelia aspera*, *Phacelia distans*, *Oenothera* (several species), *Avena fatua*, and numerous others. There is a considerable list, in the same region, of winter birds, including the western robin, Audubon warbler, ruby-crowned kinglet, American pipit, Gambel sparrow, and Brewer sparrow. Certain plants in the same district grow only under the influence of the summer rains, and a large number of birds appear only during the spring and summer period, when they breed. A number of the reptiles, amphibians, and insects, also, become active in summer only, constituting another phase of a truly seasonal aspect of the biotic community.

Variations occur in the vegetation and the animal life from year to year also. For example, on the Santa Rita Experimental Range, near Tucson, *Eschscholtzia mexicana* flowers in profusion during some winters, while in other years only a few plants appear. Similarly, the western robin only seldom appears abundantly in Tucson in winter. The cedar waxwing occurs irregularly also, occasionally becoming quite numerous, while at other times it does not appear at all.

The extreme deserts afford special cases of seasonal and annual variations in biotic communities. Buchanan (1921, pp. 104, 217) in his explorations of Aïr in the southern Sahara region north of Nigeria, found the neighborhood of Takoukout very dry in March at the margin of the bush where it gives way to the desert. In August, after the advent of "rains," a tall rank grass sprang up, the acacias produced leaves, and the Dama gazelles migrated northward into the desert margin to feed on the fresh delicate grasses. Waterfowl also appeared. The country was vastly changed from the open barrenness it possessed in the dry season. Somewhat similar observations were made by Thomas (1931, p. 220) in the great desert of southern Arabia. Settled life is nowhere possible, because of a lack of pasture. "... good pastures are nowhere perennial and sufficient. Vast tracts of desert are at any one time utterly destitute of herbage, and the abode of death for him who loiters." But certain nomadic tribes do penetrate the remoter central sands in search of grazing following rains. These instances emphasize the fact that the composition of the biotic community is in places highly variable in accordance with climatic and weather conditions. Conditions of soil and climate set the possibilities. More or less fixed is the vegetation present in these desert areas over long periods of time, in the form of spores, seeds, or other dormant plant parts. When the rains come, certain plants appear, and taking advantage of these there appear or move into the country a considerable number of insects, birds, herbivorous animals, flesh-eaters to feed on the herbivores, and even man himself. In such cases the most visible and conspicuous (perhaps sometimes the most important) parts of the biotic community may be its mobile and migratory rather than its fixed portions.

In the semi-desert and some of our desert grassland types in the southern Arizona region we consistently observe this mobility, according to season, of portions of our biotic communities. The summer rains are very irregular. Where they fall, there develops a relatively rich biota. In dry parts of the area, missed by the summer showers, the lands remain bare and seemingly nearly lifeless.

The variable composition of the biotic community according to the season is illustrated not only by the extensive areas mentioned, but in lesser habitats as well. Thus Holmquist (1928, pp. 83–84) has

given an interesting list of co-inhabitants of nests of the mound-building ant (*Formica ulkei*) near Chicago. (These include *Annelida*, *Crustacea*, *Arachnida*, *Myriapoda*, *Collembola*, *Homoptera*, *Orthoptera*, *Coleoptera*, *Diptera*, and *Hymenoptera*.) Most were attracted to the burrows for over-wintering purposes. The ants drive most of them out when they themselves become active.

In three papers on the insect inhabitants of bird houses at Bell, Maryland, McAtee (1927a and b; 1929) has listed a considerable number of animals, including a few species that occupied the nest to the exclusion of birds and many others that were in the nests at the same time as the birds. "The insects (and mites) concerned included parasites of the birds, and scavengers in the nest which themselves attracted other parasites and predators." (1927a, p. 87.) The nests were resorted to extensively in winter also (1927b, pp. 180–184).

The seasonal aspects and the annual variations of the biota are usually, perhaps always, dependent on or interrelated with a solid stratum of resident forms both of plants and animals. The groups which appear only at certain seasons or during certain years may be regarded as intrinsic parts of the biotic community of a particular area, which reach expression only under favorable circumstances (as in the case of certain resident plants and animals which are quiescent or active according to environmental conditions), or as items from the outside of the biotic community which temporarily, but in an entirely normal manner, flow into and become a part of it (migratory species). The variations in aspect and appearance then of the biota in a particular area apparently are not due to replacement of the biotic community of the area by other biotic communities from outside, but to varying expressions according to year and season of the biotic community itself *in place*. Each biotic community is a "function" of a geographic area or other locality or place characterized by a particular set of topographic, edaphic or environmental conditions. And these environmental influences, coupled with the accident of access, account for the presence of living individuals and communities.

Under the agricultural conditions prevailing over much of the earth's surface, it often happens that the seasonal or cyclical influents are of considerable economic importance. Blackbirds of several species may attack the fall rice fields on the Gulf coast or in central California, or the seventeen-year cicada may assume plague status in the Middle West.

Biotic succession, through reaction of the organisms themselves and associated physiographic processes, results in orderly replacement of successive stages in the biotic community until the climax is attained. Of course, if and when the climate changes, the climax must either migrate or undergo elimination and replacement. Thus during the advance of the glacial ice there was entire replacement of the climax biotic communities in temperate areas by those characteristic of colder regions. As the ice retreated, the reverse process took place. Short-time changes in local biotic communities may appear as the climatic cycle swings back and forth. Of course there is no permanent environment or climate, and consequently there are no unchanging biotic communities. The whole relation of community and environment is dynamic, not static.

ECONOMIC ASPECTS OF THE BIOTIC COMMUNITY CONCEPT

The concept of the biotic community (as opposed to that of the plant com-

munity alone or the animal community alone) possesses important economic as well as theoretical implications. Theoretically, of course, it avoids the erection of a barrier between plant studies and animal studies, which after all should not exist. In actual practice, the concept tends toward a well-rounded view of natural resources that cannot help but promote their better conservation and wiser use.

It is hard to segregate satisfactorily the factors operating to modify a vegetation or a biotic community. Perhaps it is not always necessary. It is highly essential, however, to recognize as many as possible of the component factors leading to an observed condition. Otherwise research may, through too great concentration on a single aspect, miss some of the critical influences involved; and administration, through imperfect understanding of the community as a whole, may, in attempted care for the resource on which attention is concentrated, neglect and even waste other resources of equal value; may, indeed, jeopardize the future conservation of all the resources, including the one that had previously been singled out.

An interesting example of what I mean is afforded in the far Southwestern United States—although the problem is not restricted to these States!—where forest, range, wild life, and agricultural developments, all stand to lose if the problems of water conservation and accelerated erosion are not solved.

The farm is properly an ecological enterprise. The ideally diversified farm is one on which there has been set up an artificial but well-balanced biotic community. Corn is grown for the hogs, and pasture grass for the cattle. Manure from the barns is returned to the land as fertilizer. The bees live on the nectar of flowering plants, which in turn are fertilized through the agency of these insects. Both plant and animal products go to sustain the life of the farm families. The less well-balanced the biotic community on the farm, the more precarious its economic future. The one-crop farmer, for example, while standing to make more money when times are good, is likely to run short perhaps a greater part of the time. What is so obviously true of the farm is equally true of science and administration of natural resources as a whole, in America and the world over. Just as the farmer's present and future prosperity depends on science, intelligence, cooperation in ever-larger units, and a well-balanced biological enterprise on his lands, so the welfare of the human race depends on science, intelligence, breadth of view, cooperation in ever-larger units, scientifically and administratively, and a well-balanced maintenance, development, and use of world natural resources.

The forest is not merely a stand of trees. It is really a biotic community and is being increasingly recognized as such. The forest manager who confines his attention to purely silvicultural aspects will not, in the long run, secure maximum returns from the land for which he is responsible. On the other hand, where forest management embodies care, not only for the trees, which must produce a part, perhaps the greater part, of the income, but also for the grasses and other plants of the forest floor (from which grazing fees may perhaps be derivable), for the wild life (from which game, fur, and recreational and other economic advantages may come), and for the soil (from which, ultimately, all the resources are derived)—where forest management embodies adequate care for all these features, forest management is sure to reach its maximum productivity.

The program of President Franklin D. Roosevelt and the Congress of the United States (spring 1933) to give work to 250,000 of the unemployed in reforestation affords an opportunity, perhaps of its kind unparalleled in the world's history, for application of ecological information. Inescapably linked with the field problems of the vast reforestation enterprise will be considerations of soil, plants now on the ground, probable effects of insects, rodents, predatory animals, birds, and game species on the seeds or seedlings, status of grazing by domestic stock, and the probable incidence of fires. Every one of these difficult problems is ecological in essence. Indeed, the success of this ambitious and promising project will largely depend on the degree to which its leaders possess the ecological point of view and succeed in getting it applied in practice.

Similarly with wild-life regulation. The conservation agency that gives its attention exclusively to particular game species will, in all probability, expend a great deal of money and effort. It may make a record for aggressive activity—but it is quite likely to fail in permanently improving the game resources of the State. In the past, game species have been repeatedly introduced, at great cost, only to disappear. Instances of wastefulness, due principally to ignorance, are all too numerous in the wild-life field. The scaled quail, native of the arid area about Eagle Pass, Texas, was once liberated at Aberdeen, Washington, where the humidity and rainfall are high. Result, failure. The Chinese quail, a migratory species, has been several times introduced in continental America. Result, failure. The only safe course to follow in wild-life management is to give attention to the entire biotic community in its environment. Conservationists in increased numbers realize that a "wild-life" agency, previous to any proposed introduction of wild species, should find out whether the place proposed to be filled by the species to be introduced is already occupied by a native species. The climatic, soil, and all the complicated plant-animal relationships should be given the closest attention and detailed study. Similar consideration should be given desirable species of game threatened with decrease or even possible extinction. Instead of thinking of protection solely in terms of bag-limit laws, seasons, and predators attention should be given to the entire complex, especially food and shelter. Since the food and shelter will largely come from plants, we again encounter the biotic community head-on. Surpluses of game in some areas have developed as a result of maladministration due to lack of applicable ecologic data. Increased numbers of citizens are realizing that wild life administration should be in the hands of capable trained biologists, and that, to secure the most satisfactory results, such officials must be liberally supported and kept on the task regardless of politics.

A vast area in the United States, indeed more than a billion acres, is devoted to range and pasture. Range management, being concerned with animals (livestock) on the one hand and forage on the other, obviously has to do with a biotic community of tremendous material value. The stock business introduces new species (domestic livestock) into natural biotic communities already often in a delicate balance. The consequences of the "fumble and success" methods of the past have little to recommend them. Frequently they have been disastrous, both to forage, wild life, and livestock. Farsighted range specialists now see that range management must not confine its attention to animal husbandry and strictly forage plants alone, but must consider every phase of the biotic community (natural and artificial) involved, since this is all a part of the essential environment.

A significant sphere in which the bio-ecological point of view promises improved results is that of watershed ad-

ministration. As a rule engineers of high technical competency are in charge of reclamation and irrigation enterprises. Inflowing streams are carefully measured, the capacity of the storage reservoir closely estimated, the construction of the dam planned to the last detail. The problem of financing the project over a considerable term of years is also elaborately and minutely calculated.

But other things than strictly engineering and financial aspects are involved in the long-time maintenance of reclamation projects. For example, what is the condition of the soil-binding vegetation on the watershed? Is livestock being permitted to overgraze the watershed, thus removing the protective soil cover, promoting accelerated erosion, disastrous flooding, and rapid filling of the reservoir with silt? Who lives on the watershed and what effect will this human population have on the project? What are the rodent, game, and recreational aspects of the watershed? Proper administration of the watershed, on the principle of greatest good to the greatest number, depends on careful weighing of values, taking into account all aspects of the biotic community in its environmental setting. If the engineer-in-charge possesses elasticity of mind and real breadth of vision, well and good. He will call into consultation bio-ecologists and will shape his plans accordingly.

Even the social and economic relations of man himself would vastly benefit from the bringing to bear on his problems of the bio-ecological viewpoint. The present-day tendency to treat sociology on an ecologic basis is sound.

Bio-ecology is responsible for two generalizations of profound import to the welfare of the human race. (1) Man cannot live to himself alone, but must care for the trees and grasses, the animals, and the world's inorganic resources as well, all of which are so vital to his existence. If man unwisely disturbs his environment he may hurt himself most. (2) Man is a member of the world biotic community and is affected, for better or for worse, by changes taking place in the status of his own or other species or their surroundings anywhere in the world. The implication is that in scientific internationalism lies the hope of the future; that recognition of the essential oneness of man and his total environment is essential; that true progress can be made only by advancing the interest of humanity everywhere.

SUMMARY

Ecologists the world over are recognizing in the biotic community (all the plants and all the animals in a given unit of environment) the true natural unit of organic life rather than the animal community or the plant community alone.

Ecology is the science of biotic communities as related to their environment.

The complex known as the biotic community may be compared to an organism, possessing a beginning, a development, and an end.

Dr. W. B. Bell of the Biological Survey suggests that the final term of a particular biotic community is properly not an "end" but rather the termination of a cycle, that even the life of an individual organism does not normally "end" but flows on unbroken from one generation to the next. This is equally true, of course, of the biotic community.

It should be pointed out that the community that may be compared most adequately to an organism is the biotic rather than the animal community (Semper) or the plant formation (Clements, earlier papers).

Plants and animals are interdependent; indeed, animals are likely to be more dependent on plants than on other animals,

and plants more dependent on animals than on other plants. Systematically, the closest relationships are with the creatures nearest in the line of descent, i.e., an animal is most closely related to some other animal. Ecologically, the closest relationships are likely to be with some species remote in the line of descent, i.e., an animal is most intimately dependent upon a plant, and vice versa.

Biotic communities cannot be rigidly defined or classified. They are of all grades, from the closely circumscribed communities in limited localities, to the world biotic community including all living forms. The problem is not to make living creatures fit any special scheme of biotic communities, but to make the biotic communities conform to living organisms.

Seasonal and annual variations in the biotic community are conspicuous and often important. Groups of organisms which appear in a given biotic community only at certain seasons or in certain years may perhaps best be regarded as intrinsic parts of the biotic community which reach expression only under favorable circumstances.

The concept of the biotic community possesses far-reaching implications in all the enterprises of economic biology, as forestry, range administration, wild-life management, and agricultural operations generally, not to mention in detail the social sciences.

It is not too much to assert that bringing to bear the bio-ecological point of view offers the best assurance we can have that each unit of area will be so administered as to produce at a maximum and still maintain its capacity to produce. The emphasis placed by bio-ecology on organism and environment as a great unitary system is an inspiring one, and should lead to a more profound insight into many problems in diverse fields of human interest and larger contributions to human welfare.

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He also wishes to express his appreciation of the advice and help of J. F. Breazeale, of the Bureau of Plant Industry, Tucson, Arizona; and of Hermann Krauch, of the Southwestern Forest and Range Experiment Station, Tucson, both of the United States Department of Agriculture.

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DIFFERENTIAL REPRODUCTION IN CHINA

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INTRODUCTION

THE problem of *differential reproduction*, or *differential fertility* as it is termed by some and *differential fecundity* by others, has been studied by eugenics and by sociology for some time as it concerns the different social classes. A considerable body of literature in this field has accumulated, the results of which, for the most part, seem to show that the upper economic classes in Western society are not reproducing themselves as rapidly as are the lower. Since there are many data to show that it is from these upper economic classes that a larger proportion of men of superior ability is produced, the conclusion is reached that this situation is dysgenic. It is not the purpose of the writer to go into this matter for Western countries, but rather to bring forth evidence concerning this problem as it reveals itself in China. While at the outset it must be admitted that statistics for China are few and probably not as reliable as those in the West, yet there is material worth considering and which gives us a picture somewhat different from that found in the West. I shall try to show that in China the upper economic classes have more children per family than the lower economic classes; that modern education tends to *increase* rather than to *decrease* the number of offspring per family.

SIZE OF FAMILIES FROM WHICH STUDENTS COME

There have been a few studies of small groups of families of students in China which give us some idea of the number of children in families of the middle and upper economic classes. These studies have been carried on among Middle School and College students who have to pay a considerable amount in school fees, which fact automatically selects them as being not of the class of coolies, factory operatives, or other very low income groups. The fact that these data were secured through the students themselves means that only families with at least one child could be included. The figures which I shall quote in this section will, therefore, represent only families which have at least one child and which belong to the classes able to send their children to Middle School. It will be observed from a study of Table 1 that in the six studies of families of Middle School and College students the average number of living children falls in general between four and five; the average number of dead children between one and one-half and two; and the total births a little more than, or approximately, six. It is quite likely that in these families a certain number of miscarriages, stillbirths, and abortions have been omitted through failure of the reporting students either to know or to state such facts concerning the puerperal

history of their mothers. Thus it is quite likely that the total number of births reported is smaller than the total number of pregnancies occurring. That differentials prevail even within this fairly homogeneous group of families will be shown later when the education of the parents is analyzed.

SIZE OF FAMILIES AMONG LOWER ECONOMIC GROUPS

For the moment let us leave the educated families and turn to lower economic groups. I have gathered into a table a number of scattered studies made in China

TABLE 1

Average Number of Children in Families of Middle School and College Students in China

INVESTIGATOR	NUMBER OF FAMILIES	AVE. NO. LIVING CHILDREN	AVE. NO. DEAD CHILDREN	TOTAL BIRTHS
Griffing (1)	252	4.32	1.62	5.93*
Griffing (2)	310	3.98	1.79	5.75*
Lamson (3)	1778	4.81	⁂	⁂
Lamson (4)	1781	5.03	1.60	6.63
Milam (5)	800+	4.41	2.10	6.51
Oppenheim (6)	473	4.22	1.74	5.96

* Griffing's totals do not exactly represent the sum of the two parts within .02, but these are as he gives the total averages.

⁂ Data relative to dead children not secured.

aiming to discover the reproduction rate among such families. In Table 2 attention is called to the relatively small number of living children which, even in those families in which the marriage has lasted for eighteen or twenty years, never rises above three, although the cases of Gray, Griffing, and Lamson comprise only families having children and where the information is secured through the mothers chiefly.

In the study of 4,000 married men made by Dr. Lennox he found, as these men came to the out-patient department of the Peiping hospital, that 958 had no children (24 per cent). This group of 958 men had been married an average of 5.5 years; whereas the 3,042 having children had been married 14.5 years. But even these having children, and having been married nearly fifteen years, had only 1.8 living offspring, and a total of 2.7 births. It is, of course, possible that these fathers omitted some pregnancies which occurred in their families but which did not result satisfactorily.

Dr. Lennox made another study of family size, but this time he investigated the number of children of a highly educated group,—171 modern-trained Chinese physicians whose average age was 36.2 years and who had been married an average of 11.1 years. This group of men had 3.46 living children. Thus we note that this selected educated group (probably also from rather well-to-do families) had as the result of 11 years of married life nearly twice as many living children per family as the 3,042 married men of lower economic class who had been married more than three years longer, on the average (11). In this connection Dr. Lennox comments, "Even though educated Chinese are not married until age 25 (Chinese count) they have children at a rate which will give seven children to the family, if

marriage lasts through 21 years of the wife's child-bearing period."

Returning to the study of 4,000 lower class fathers by Dr. Lennox we find that, taking the 1,148 fathers who were married before they were 26 years old and married more than 15 years, there were 3.4 children on the average per father. Of these 1.1 had died leaving 2.3 living per family. The author concludes, "On the whole, these figures show that the Chinese lower classes have much smaller families than is generally supposed."

I made a small study in Shanghai in 1933 of a group of amahs (women servants) aiming to discover facts relative to family size both of the amahs themselves and of their mothers. Some of the results are shown in the last two lines in Table 2. In the case of the amahs themselves we find 63 who are married and have children. Seven are married but have no children; two are unmarried; and two are in their first pregnancy. We have included only the 63 in the last line of the table. The 72 amahs were asked whether or not they desired any more children, to which 39 replied negatively, and 33 affirmatively. The data for those *not* desiring further offspring are as follows: average age, 42.5 years; average pregnancies, 3.89; average living children per woman, 2.17. The figures for those women who desire more children are: average age, 32.1 years; average pregnancies, 2.51; average living children, 1.36. If we count the number of children this last class of women have *living* and add the number they *desire* in addition we find that the *total wanted* averages 3.7 children, slightly less than the total average pregnancies of those who do *not* want any more, 3.89.

TABLE 2

Number of Children of Middle and Lower Economic Groups and Those with Little Education in China

INVESTIGATOR	TYPE OF FAMILIES	NO. OF FAMILIES	AVE. LIVING CHILDREN	AVE. DEAD CHILDREN	AVE. TOTAL CHILDREN	AGE OF SPECIFIED PARENT	DURATION OF MARRIAGE
						years	*years*
Lennox (7)	Peiping lower & middle	4,000	1.4	0.7	2.1	32.8 Father	12.3 (A)
		3,042	1.8	0.9	2.7	?	14.5 (B)
Gray (8)	Charity hospital mothers	1,000	2.3	2.4	4.7	Mother about 40	20.0
Hammond & Hsu (9)	Peiping largely middle	903	2.6	1.1	3.7	?	?
Griffing (2)	Rural uneducated	220	2.99	2.33	5.32	Mother 39 or over	At least 20 years
Lamson (10)	Amahs' mothers' children	74	2.77	2.42	5.19	?	Families probably complete
Lamson (10)	Amahs' own children	63	2.06	1.62	3.68	Mother 37.7	About 18 years

A—Total married men. B—Those with children.

There have been made in China several small studies of families of lower economic groups such as coolies, factory hands, common peasants, from the point of view of the standard of living. Most of such studies, which we have not space here to quote in detail, give the total number of persons in the families, or averages which show us the total number of *persons* living together in a family unit. The figure runs from about 3.5 to 6.00 persons, with four and five the more common number. *If* these families consisted only of two parents and offspring the average number of children would then be between 1.5 and 4.00, with two and three the more common number, *but* we cannot make this assumption since in some families one parent is dead, and uncles, cousins, or grandparents may be present. This being so, the number suggested for offspring would have to be still further reduced.

DIFFERENTIAL REPRODUCTION BETWEEN UPPER AND LOWER GROUPS

We have discussed the size of family of certain upper economic class groups and also of certain lower groups. It now remains to put together from these studies certain comparative material by age groups in order that the contrasts in reproductive rates can be more clearly observed. Unfortunately we have to deal with studies which are not standardized in all respects. The samples are from different places, by different investigators, of different sizes, and of age-groups which do not precisely correspond, but even so this seems to represent a worthwhile preliminary attempt at analyzing what material we have. Table 3 gives the details from which Chart 1 is drawn.

It will be noted in Chart 1 that for each of the four age groups both the average number of surviving offspring and the total births per family for the upper economic groups are considerably in the lead over the lower economic groups. This chart seems to reveal dramatically the reverse of the differential reproduction situation in the United States.

NUMBER OF OFFSPRING AND EDUCATION OF PARENTS

In Table 1 data were presented showing the number of children in families of Middle School and College students in

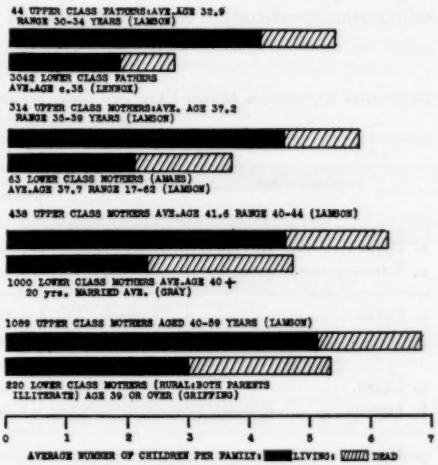
44 UPPER CLASS FATHERS: AVE. AGE 32.9
RANGE 30-34 YEARS (LAMSON)
3042 LOWER CLASS FATHERS
AVE. AGE 0.36 (LENNOX)
314 UPPER CLASS MOTHERS: AVE. AGE 37.2
RANGE 30-39 YEARS (LAMSON)
63 LOWER CLASS MOTHERS (AMARS)
AVE. AGE 37.7 RANGE 17-62 (LAMSON)
436 UPPER CLASS MOTHERS AVE. AGE 41.6 RANGE 40-44 (LAMSON)
1000 LOWER CLASS MOTHERS AVE. AGE 40 +
20 YRS. MARRIED AVE. (GRAY)
1089 UPPER CLASS MOTHERS AGED 40-59 YEARS (LAMSON)
220 LOWER CLASS MOTHERS (RURAL: BOTH PARENTS ILLITERATE) AGE 39 OR OVER (GRIFFING)
0 1 2 3 4 5 6 7
AVERAGE NUMBER OF CHILDREN PER FAMILY: LIVING: DEAD

CHART 1. DIFFERENTIAL REPRODUCTION BETWEEN UPPER AND LOWER ECONOMIC GROUPS IN CHINA, ARRANGED BY CORRESPONDING AGE GROUPS, INCLUDING MARRIED PERSONS WITH CHILDREN ONLY

China. I now propose to give further details to show that even in this group which has been designated roughly as "upper economic group" there are differentials which further substantiate the main thesis of this paper.

In Chart 2 I have presented in a graphic form data concerning education of the mother and of the father in relation to number of living and dead offspring as found by Griffing in his studies of families of mothers of students in East China. It

will be noted that where both parents are literate both the average number of surviving children and total births are higher than in the case of families in which one or both parents are illiterate.

In Chart 3 there is given material from other studies by Griffing, these having been made by direct survey in rural districts in East China. In this case nearly all mothers are illiterate. There is a regular rise in the number of surviving children as we proceed from the 220 families in which the husband has no education up through the 61 families in which he has from one to four years schooling, to the 164 families in which the husband has five or more years of education. In the case of the total births the rise is irregular. However, both groups in which the husband has some education show a higher average of births per family than the group in which the husband is without education.

In Chart 4 I have graphically presented Griffing's findings from the students in two colleges and one middle school in Nanking (1). The figures to the left of the bars show the average number of living children, number of dead offspring, and total births per family in the groups as stated. It will be observed that the group having the highest number of living children and total births is that in which both parents are Christian and educated. Without regard to education, families in which the parents are Christian are larger than those which are non-Christian. These contrasts are shown in the upper three bars. When the families are arranged according to literacy of parents without regard to religious affiliation we again note the regular rise both in living children and total births as we go from the 15 families in which both parents are illiterate to the 116 in which only the mother is illiterate, and to the 112 families in which both parents are literate. This study seems to show that families with most education and most Western influence in their lives (as shown by taking on a new religion) have the largest number of offspring born and surviving.

Having quoted the results of studies by J. B. Griffing I shall now give material from my own studies which confirm his general results. Table 4 presents figures

TABLE 3

Differential Reproduction between Upper and Lower Economic Groups in China Arranged by Corresponding Age Groups, Including Married Persons with Children Only

ECONOMIC CLASS	INVESTIGATOR	NUMBER OF FAMILIES	BY AGE OF WHICH PARENT	AGE OF SPECIFIED PARENT (*years*)		AVERAGE NUMBER CHILDREN PER FAMILY		
				Average	Range	Living	Dead	Total
1. Upper	Lamson (4)	44	Father	32.9	30–34	4.11	1.25	5.36
2. Lower	Lennox (7)	3,042	Father	35.0	?	1.80	0.90	2.70
3. Upper	Lamson (4)	314	Mother	37.2	35–39	4.51	1.26	5.77
4. Lower	Lamson (10)	63	Mother	37.7	17–62	2.06	1.62	3.68
5. Upper	Lamson (4)	438	Mother	41.6	40–44	4.57	1.68	6.25
6. Lower	Gray (7)	1,000	Mother	40+	?	2.30	2.40	4.70
7. Upper	Lamson (4)	1,089	Mother	?	40–59	5.10	1.74	6.84
8. Lower	Griffing (2)	220	Mother	?	39 up	2.99	2.33	5.32

showing the rise in average number of living children (living at the time the study was made) for a group of 307 mothers of eight Shanghai Middle Schools, and for 545 fathers; the increase being from the less educated to the more educated. This group of families averages 5.06 or 5.15 living children and represents those in which the parents have some degree of modern-type education. Since

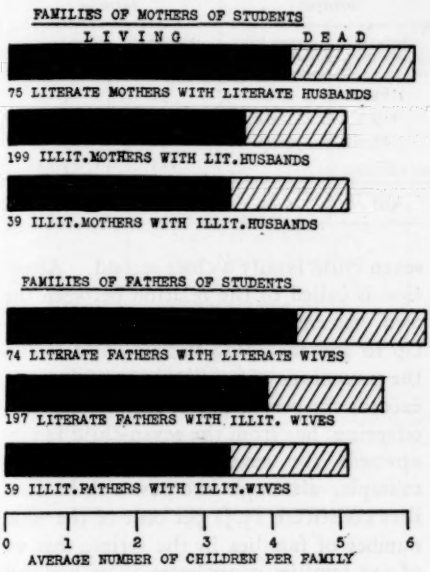
FAMILIES OF MOTHERS OF STUDENTS
LIVING
DEAD
75 LITERATE MOTHERS WITH LITERATE HUSBANDS
199 ILLIT.MOTHERS WITH LIT.HUSBANDS
39 ILLIT.MOTHERS WITH ILLIT.HUSBANDS
FAMILIES OF FATHERS OF STUDENTS
74 LITERATE FATHERS WITH LITERATE WIVES
197 LITERATE FATHERS WITH ILLIT. WIVES
39 ILLIT.FATHERS WITH ILLIT.WIVES
0 1 2 3 4 5 6
AVERAGE NUMBER OF CHILDREN PER FAMILY

CHART 2. EDUCATION OF PARENTS AND NUMBER OF OFFSPRING, EAST CHINA

(Studies by J. B. Griffing)

the average living children for the whole series of 1778 families comes to 4.81 we can see that this small group, in which the parents do have this modern training, contains larger families than the remainder in the study. In this particular study data relative to dead children were not secured.

In Table 1 at the beginning of this paper a second study by the present writer was mentioned. I now desire to analyze this in a similar manner, as it seems to show that education does not cut down, but rather seems to increase, fertility. This

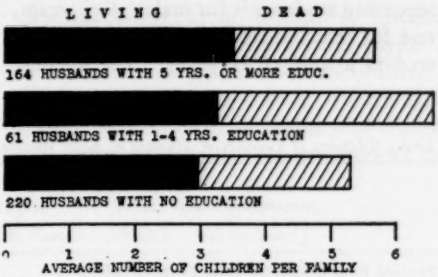
LIVING
DEAD
164 HUSBANDS WITH 5 YRS. OR MORE EDUC.
61 HUSBANDS WITH 1-4 YRS. EDUCATION
220 HUSBANDS WITH NO EDUCATION
0 1 2 3 4 5 6
AVERAGE NUMBER OF CHILDREN PER FAMILY

CHART 3. FAMILIES OF MATURE MOTHERS IN RURAL AREAS; MOTHERS NEARLY ALL ILLITERATE (EAST CHINA)

(Studies by J. B. Griffing)

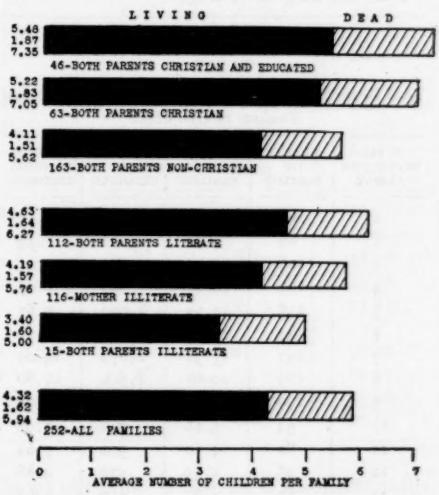

CHART 4. COMPARISON OF FAMILIES OF MOTHERS OF STUDENTS IN NANKING; AVERAGE NUMBER OF CHILDREN BY EDUCATION OF PARENTS

(Studies by J. B. Griffing)

is not to be taken as meaning that more education "causes" increased fertility, but that it certainly is associated with it. The study was made in East China in fifteen Middle Schools; one in Kinhwa,

three in Soochow, and the remainder in Shanghai. Table 5 gives the distribution according to size.

In this study the average age of the reporting students is for males 16.91 years, and for females 16.69, both sexes considered as a unit 16.82 years. The average age of parents is 44.43 years for mothers and 47.31 years for fathers. The average number of living children per family is 5.03; children who had died 1.6; and total births 6.63 per family. As will be noted from Table 5 the modal size for total births is the six-child family, with the seven-child family a close second. Attention is called to the relation between the two percentage columns in this table. Up to and including the six-child family the percentage of families to total families exceeds the percentage of children to total offspring; but from the seven-child family upwards the reverse is the case. For example, although the seven-child families constitute 13.31 per cent of the total number of families in the series, this set of 237 families contributes 14.05 per cent of all the children. And although the 218 five-child families constitute 12.24 per cent of all families they contribute but 9.23 per cent of the total children. The table contains no childless families since information was secured through Middle School students concerning their own brothers and sisters.

Table 6 presents an analysis of these 1781 families according to education, as far as that information was given. The average number of children is arranged according to (1) the education of the mothers, and (2) the education of fathers.

TABLE 4

Living Offspring of Families of Students of Eight Middle Schools in Shanghai According to Education of Parents (3)

EDUCATION OF STATED PARENT	MOTHERS		FATHERS	
	Number of families	Average living children	Number of families	Average living children
Studied in or graduated from Primary School	165	4.88	97	4.65
Studied in or graduated from Middle School	119	5.14	192	4.98
Studied in or graduated from College	23	5.91	131	5.29
Studied abroad	—	—	125	5.44
Total and Weighted Average	307	5.06	545	5.15

TABLE 5

Total Births per Family in 1781 Families of Middle School Students in East China

TOTAL BIRTHS PER FAMILY	NUMBER OF FAMILIES	PER CENT OF TOTAL FAMILIES	TOTAL NUMBER OF CHILDREN	PER CENT OF TOTAL CHILDREN
1	65	3.65	65	.55
2	88	4.94	176	1.49
3	128	7.19	384	3.25
4	180	10.11	720	6.09
5	218	12.24	1,090	9.23
6	244	13.70	1,464	12.39
7	237	13.31	1,659	14.05
8	189	10.62	1,512	12.80
9	130	7.29	1,170	9.91
10	94	5.28	940	7.96
11	82	4.60	902	7.64
12	48	2.69	576	4.88
13	33	1.85	429	3.63
14	15	.84	210	1.79
15	9	.51	135	1.14
16	6	.34	96	.81
17	5	.28	85	.72
18	3	.17	54	.46
19	2	.11	38	.32
20	2	.11	40	.34
21	2	.11	42	.36
22	1	.06	22	.19
Total...	1,781	100.	11,809	100.

An added column is to be noted which shows the percentage of children that have died in the families. Both in the groups arranged by mothers' education and in those arranged by that of the fathers we note that those parents recorded as having had no education have a higher proportion of dead children than the others. In the case of families arranged by mothers this runs from 26.92 per cent for mothers with no education to 24.16 for mothers with some private (presumably old style) education, and to 22.44 for those with some modern schooling. Corresponding figures for fathers are: 28.18 to 25.91 to 23.65 per cent.

Both in the case of the families arranged by fathers and by mothers we find that parents with *some* education have a larger average number of living and of total children than those with none. However, it may be pointed out that the difference is not great, the total average number of children being above six. In this connection it should be mentioned that in this group of families of Middle School students the term "No Education" is not to be interpreted as meaning illiterate coolies or factory hands. There is a considerable number of families in China which are financially able to send one or more children to Middle School and who at the same time have mothers or fathers without education. As Table 6 shows, this class is much larger among mothers than among fathers, the figures being 503 to 69. This is not surprising when we call to mind the fact that education for women in China, traditionally, has not been given the emphasis that education for men has received.

In the case of the families arranged by

TABLE 6

Education of Parents and Number of Children, Families of Middle School Students (4)

NUMBER OF MOTHERS	TYPE OF EDUCATION	AVERAGE CHILDREN PER FAMILY			PER CENT DEAD CHILDREN
		Living	Dead	Total	
	FAMILIES ARRANGED BY EDUCATION OF MOTHER				
503	No Education	4.61	1.70	6.31	26.92
418	Some Private Education	5.17	1.64	6.82	24.16
485	Some Modern Education	5.10	1.48	6.58	22.44
159	Primary School	4.52	1.47	5.99	24.54
260	Middle School	5.11	1.36	6.47	20.97
34	College	5.44	1.50	6.94	21.61
32	Study Abroad	7.62	2.47	10.09	24.45
NUMBER OF FATHERS	FAMILIES ARRANGED BY EDUCATION OF FATHER				
69	No Education	4.65	1.82	6.47	28.18
535	Some Private Education	4.98	1.74	6.73	25.91
858	Some Modern Education	5.13	1.59	6.72	23.65
83	Primary School	4.95	2.35	7.30	32.16
279	Middle School	5.20	1.76	6.96	25.33
232	College	4.74	1.31	6.05	21.58
264	Study Abroad	5.47	1.42	6.89	20.62

education of mothers in Table 6 we find, when we break up the 485 in which the mother has had some modern education, that there is an increase both in living and in total average children as education increases. This tendency is not as apparent in the corresponding figures for fathers. It may be suggested by way of explanation that in the case of educated mothers there is much more likely to be an educated father (that is, husband) than that all educated fathers will have educated wives. In other words, in those families in which the mother has some modern education the chances are greater that both parents will be educated than in those families in which the father is educated. The reason for this is that educated women do not want, and may even refuse to accept, husbands with education inferior to their own; whereas educated husbands may, owing to the greater relative scarcity of educated women, be forced to marry a woman without education, or at least with education considerably inferior to his own. In fact, a highly educated man may prefer to have a wife whose education is inferior to his for various subtle reasons. This is offered as a possible reason for the greater regularity in the rise of the number of children (as education increases) in the mothers' column than in the fathers'.

In the study of student homes in China by Milam (5), mentioned in Table 1, it was found that for the 259 families whose annual incomes averaged $1000 (Chinese currency) or above, the average number of living children was 5.5; dead children, 2.1; and total births, 7.6. Corresponding figures for 292 families whose annual incomes averaged less than $1000 came to 4.3 living; 2.1 dead; and 6.4 total births.

In the other studies of students' families income was not ascertained. Students do not seem, in general, to give very reliable data in regard to the income of their parents; for this reason the present writer has not included such data in his studies. We can infer in a rough manner that families which send their children to middle school and college are in a better economic situation than domestic servants and factory operatives. The facilities for "working your way through" school are not as numerous in China as in the United States. It is impossible at present to ascertain with exactness which of several variables is responsible for the differential rate of reproduction which seems to exist in China. It is quite likely that several variables are functionally related: income, degree of education, environmental conditions, inherent ability, and fertility.

It is of further interest to note that, in both of the studies which I made in East China, of all occupations of fathers of Middle School students physicians show the highest average number of children. In the 1781-family study the 61 physicians, although averaging only 46.47 years, have 6.13 living children, 1.51 dead, and 7.64 total births per family. In the same study 121 fathers listed as "agriculturalists" (rural dwellers, landlords, farmers) average 50.86 years and have 4.95 living, 1.67 dead, and 6.62 total children.

AGE OF PARENTS AND NUMBER OF OFFSPRING

In this study of 1781 families we may briefly summarize the findings in regard to age classification. Since the material was secured through students in Middle School whose minimum age was 10 we may say that our families have been married at least 11 years. This gives us relatively few parents under thirty years of age. Fathers in their thirties have an average of 5.89 births in their families; those in their forties, 6.54; in their fifties, 7.4; in their sixties, 7.88. The six fathers in their seventies average each eight children.

The average number of both living and dead children increases with the age of the father. The same general phenomenon appears in the case of the families arranged by age of mothers. Mothers in their thirties have in all 5.97 births; those in their forties, 6.68; in their fifties, 7.20; and in their sixties, 7.53. The 56 families in which the mother is reported as dead have a still higher number of births, averaging 8.8. If we consider the families of mothers in their fifties or above we find that the average total births is well above seven, and in the case of the dead mothers nearly nine.

Comparing the total number of children, living and dead, for each of the four significant age groups according to fathers and mothers respectively, we see that the fathers have a smaller average number of children than the mothers in the thirties and forties, but that the fathers are ahead in the fifties and sixties.

I wish to report briefly upon another study (12), dealing with age and number of offspring, made in Shanghai through a class of women college students who collected information from their relatives and friends (women) who were married and for the most part women of some education. Information was secured for 120 such women. For these we find the average number of pregnancies rising from 1.89 to 3.44 to 6.33 as the average length of marriage increases from 3.07 years to 7.62 to 13.33 years. Since these women were on the whole relatively young we do not have many cases of those married more than fifteen years. There are seven women married over 25 years and these have an average of over seven pregnancies. For the first three age groups the average number of living offspring (at the time of the study) rises from 1.48 to 2.59 to 4.28 as the average age of the mothers increases from 24.93 to 30.15 to 34.44 years.

The number of married years *per pregnancy* for those 54 women married 1–5 years comes to 1.63 years; for the 27 women married 6–10 years the corresponding figure is 2.22; for the 18 women married 11–15 years 2.11; for the 8 women married 16–20 years 3.6; and for the 6 women married 21–25 years there is one pregnancy on the average for every 3.5 years married. In this series of 120 married women whose average age was 30.73 we discovered out of 447 pregnancies four admitted abortions and 32 miscarriages. This gives us a hint that in our other studies of over 1700 families there must have been a considerably larger number of pregnancies than of total births.

AGE AT MARRIAGE

Information regarding age at marriage is rather fragmentary. We do not have space here to include a few tables available from small studies. In general we may say that among those groups in contact with modern ideas the age at marriage is gradually rising, both for female factory operatives (13) and of course for those educated classes with whom attendance at college and graduate schools is becoming more common. In the study made by Dr. Lennox of 4,000 married men of middle and lower classes, the largest number of men married at age 19 (Western reckoning), with 18, 17, 16, and 20 following in that order. This same investigator found among modern Chinese physicians a range of age at marriage from 14 to 46 averaging 24.7 years, with the mode at 26 years. Dr. Lennox stated that of his 4,000 men of middle and lower classes 54 per cent married before age of 20 but that these had no more children than those marrying after age 20.

In my study of 72 amahs (lower economic class) age at marriage ranged from 14 to 25 (Western reckoning); the largest

number occurred at 18, age 17 and 16 nearly tying for second place. The 17 amahs marrying in the decade 1924–1933 averaged 18.8 years at marriage; the 11 marrying in the decade 1894–1903 averaged 17.9; and the six women married between 1884 and 1893 averaged 17.5 years at marriage.

In my study of the 120 educated married women there is noted a rising age at marriage. The general average is at 21.44 years. For the 81 women married ten years or less, wedded in the decade 1921–1931, the average age at marriage is 22.07. For the 26 cases marrying in the period 1911–1921 the figure is 20.76; and for the ten women married in the decade 1901–1911 the mean age at marriage is 18.9 years.

The rather rapidly expanding opportunities for careers for women in China, whether in factories or in the professions, means postponement of marriage, and for some it means that they will never marry. Under the traditional system everyone in the community was expected to marry and parents made the arrangements; now with a rapid increase of Western influence young persons, especially in towns and cities, seek to choose their own mates, or may even choose not to marry. However, strong traditions of family life still prevail even among the educated. We do not know what proportion of the people do not marry, nor do we know what proportion of college girls remain single. Coeducation and special institutions of higher learning for women are of such recent development that the time is not yet ripe for comparative studies with those in the West.

FAMILY LIMITATION AMONG EDUCATED CLASSES

Elsewhere (12) I have attempted to secure information relative to family limitation for two groups of educated Chinese women. In one of these (the Shanghai study of 120 married women) it was found that nearly all of the women stated that they had known women whose too-frequent childbearing had resulted in deterioration of health of the mother. About nine-tenths of these women believed that women in general should be able to regulate the coming of their children and expressed themselves as being willing to receive contraceptive information. As nearly as could be determined, not more than about 17 per cent of the women had knowledge of modern contraceptive methods.

While our figures tend to show that education does not cut down fertility among those families with at least one child, but rather seems to be associated with increased rate of reproduction, yet we have to admit that gradually this knowledge of birth control is spreading and the idea of smaller families is penetrating. Books on birth control have been translated into Chinese; an experimental clinic has started in Peiping; educated Chinese appreciate the dangers of an overcrowded population; some drug stores sell contraceptives; those of the student class about to be married are asking to be directed to contraceptive information. These are straws in the wind and it is quite possible that the conditions described in this paper may be reversed after a period of years has elapsed. One thing seems fairly certain, namely, that knowledge of methods of contraception will penetrate, are penetrating, among upper economic classes before they reach the lower classes. Abortion, infanticide, neglect, and sale of children still remain, of course, as means by which the lower class families may rid themselves of surplus mouths.

THE SECONDARY MOTHER

The question may have occurred to someone, "Since the more highly educated classes are the ones which have the most money, may it not be possible that the birth differential is due to plural wives in the same family?" From the data secured in my study of 1781 families of Middle School students the answer is in the negative. Here I can consider this question only very briefly, although I hope to present more details in a later article. Out of 1781 families 202, or 11.34 per cent contained one concubine or more. The total number of concubines came to 256, making an average of 1.26 per family having these secondary mothers. Although families with a concubine constitute 11.34 per cent of all families, they produce only 9.21 per cent of all children. (This means that this amount is produced by the family in which the concubine is found, not the production of the concubines alone.) Of all the births in the 1781 families the "big wife," or the first wife, produces 92.53 per cent, more than nine-tenths. Stepmothers produce 3.27 and concubines 4.2 per cent of all births.

In our 1781 families there are 1579 with no concubine; 166 families with one; 26 families with 2 each; six families with 3 each; one family with 4; two with 5; and one with 6 concubines. The average number of births in families with no concubines is larger (6.79) than for any of the groups having one or more concubines, except the one family with five concubines. The 166 families in which there is one concubine each, average 5.2 total births per family. The 26 families in which there are two concubines each, average 5.92 children (living and dead) per family. And the six families in which there are three concubines each, average 6.5 children. These are rather unexpected findings which we do not have space here to discuss in detail. We may conclude that, as far as our series is concerned, differential reproduction is not to be explained by the secondary mother.

FINAL CONSIDERATIONS

If we grant that there are different reproductive rates apparent between the upper and lower economic classes in favor of the upper, what are the possible explanations?

(I) That there is a difference in *conception* rates.
  (A) Extrinsic factors: (1) Greater incidence of disease among lower classes; (2) Possibly greater proportion of unmarried among the poor; (3) Nutritional defects greater; (4) Psychological effects of poor environment; (5) Greater density of population per room among the poor (Cf. R. Pearl's theories).
  (B) Intrinsic factors: (1) Greater proportion of childless among poor; (2) Prolongation of nursing period among lower class mothers; (3) Lower physical vitality; (4) An established evolutionary biological difference in innate ability, including fertility, among the classes.

(II) That there is no difference in the rate of conception, but that the difference begins to be noticed in the *birth* rates.
  (A) Economic pressure impinges more heavily upon the lower economic classes and leads to a larger proportion of unsuccessful pregnancies: (1) Through artificially induced miscarriage (abortion) wilfully undertaken by the mother or midwife; (2) Through accidental miscarriage brought on by hard work, accidental injury, or some vital deficiency; (3) Through a larger proportion of stillbirths and birth trauma cases, due to unskilful assistance or lack of aid at birth.
  (B) That the traditional belief in the importance of a large number of offspring (especially sons), plus financial ability to carry this into effect, is stronger among upper economic groups, leading to relatively less wilful interference with pregnancy.
  (C) Or that these traditional beliefs are equally strong in all classes, but that economic pressure forces the lower classes to limit the number of births through abortion.

(III) That there is no difference in conception rates or

in birth rates, but that there is a difference in *survival* rates.

(A) Greater amount of infanticide among lower classes: (1) Through outright destruction of life; (2) Through gradual neglect due to lack of interest in having that child survive.

(B) Greater amount of deaths soon after birth from: (1) Ignorance of proper child care; (2) Inability to furnish the child with what it needs, among the lower economic groups.

(C) Greater proportion of child deaths at varying ages among the poor due to: (1) Accidents through lack of care by mothers working away from home; (2) Sickness due to unhealthful surroundings; (3) Death from ignorance or inability to secure medical attention; (4) Superstitious practices ending in death.

(D) Greater failure among poor to report pregnancies or births which miscarry, are stillborn, or which die soon after birth, such happenings not being regarded as "children."

Considerable further research is needed to prove or disprove some of the above points. I am inclined to believe that all three of these major factors enter into the picture (conception rates, birth rates, and survival rates). There would seem to be no question (1) that the upper economic classes have greater survival rates. It is fairly certain (2) that the upper economic classes who are married have a higher birth rate than the lower who are married. We do not know the relative proportion of unmarried in the classes, nor do we know the differential in the number of childless marriages. (3) There are still less certain data as to whether the lower economic classes actually have a lower conception rate or not. However, I hazard the inference from this paper that there is a strong probability that even in conception rates a differential favoring the upper classes is present.

Turning now from the particular considerations to more general theoretical subjects concerning upper and lower economic classes in China, the following observations are made as having a bearing.

(1) Assortive mating has been and seems to be going on; since marriages under the old system were made by the parents through a middleman it is probable that there has been more intra-class than inter-class mating. (2) This would tend in time to bring about a real biological cleavage between the social classes (14). (3) Even among modern educated groups in China among whom parental arrangement for marriage is becoming less common, there is still a tendency for marriage to keep within certain class lines. (4) Calamities such as civil war, famines, floods, plagues (while they may kill off the weaker, yet upon those who do survive) may have a weakening effect which is more noticeable among the poor, who are less able to get away from the scene of the trouble, or to rehabilitate themselves afterwards. (5) There is some vertical mobility continually taking place between the classes. Bright boys from among the peasant class, for example, have been selected and given an education with the definite idea that they will rise above their relatives and perhaps become scholars or officials. This has brought capacity and ability from lower to upper classes. On the other hand, the rich opium addict may gradually smoke away all his possessions and be reduced to beggary.

These general remarks are intended to propose the thesis that *one* of the reasons for the favorable and eugenic differential reproduction rates among the upper, educated, classes in China is to be found in an innate biological superiority, including greater reproductive power, of the upper economic classes over the lower. Differential reproduction at present seems to be eugenic in China.

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THE ELECTRO-DYNAMIC THEORY OF LIFE

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THERE are several factors which suggest that living things must be viewed from the electro-dynamic point of view. Certain of these factors appear in the non-biological sciences and in general philosophical considerations; others arise in biology itself, and particularly in connection with recent evidence concerning the factors controlling the development of the nervous system.

I. GENERAL SCIENTIFIC AND PHILOSOPHICAL CONSIDERATIONS

If one views the history of science as a whole, including its Greek as well as its modern manifestations, a certain contrast appears. Greek science was dominated largely by mathematics and astronomy, whereas since the seventeenth century physics and chemistry have been the leading disciplines. This difference in emphasis among the special sciences bespeaks a more fundamental difference in scientific outlook. Mathematics and astronomy as they appeared in Greek times in the geometry of Euclid and in the mathematical astronomy of Eudoxus, were systematic deductive sciences dealing with the entire spatial and astronomical universe as a whole. It is an obvious peculiarity of geometry as a pure science that it is concerned wholly with structure and not at all with matter. It is a more unexpected peculiarity of astronomy that it, more than any other of the natural sciences, tends to conceive of nature as a purely formal system. This was the case in Greek times and with Kepler, and is, or was, the case in our own time with Eddington and Jeans. It was not the case, however, with Galilei and Newton. They conceived of the astronomical universe as a physical system analogous to the system of earth and ball and inclined plane with which Galilei verified his profound and revolutionary reflections.

This brings us to the sharp contrast between traditional modern science and Greek science. The latter, dominated as it was by such scientists as Eudoxus, Euclid, Apollonius and Archimedes, tended to regard mathematics as more fundamental than physics and to think of nature as a purely formal structure; the former, following Galilei and Newton, made physics primary, and hence regarded nature as an aggregate of many physical objects in motion, mathematics becoming a very necessary means, but nevertheless merely a means, of precisely formulating this physical conception. Stated in more general philosophical terms, Greek science, including biology with Aristotle, tended to conceive of nature in terms of formal causes; modern science, in terms of material causes. The two views have not been compatible in traditional scientific or philosophical theory. To maintain that nature is a system of forms, unconditioned by matter, is to maintain that nature and its systems possess a changeless structure; hence, the doctrine of the fixity of biological types in Greek biology. To maintain that nature is a collection of physical objects in motion is to regard structure as a relation between these objects, and subject to change with their motion; hence, the essentially modern character of Darwin's doctrine of the modification of biological types. In

short, Greek inorganic and organic science put the emphasis on structure and the eternal constancy of forms whereas modern science has placed the emphasis on physical and chemical and biological entities and the variability and evolution of forms.

This difference between Greek and modern science exhibits itself in one contrast which is implicit in what we have already indicated. The ancient emphasis on structure and on systematic science, such as appeared in the geometry of Euclid and the astronomy of Eudoxus, led to the conception of nature as a single system. This means that no local system can be completely understood by itself and that thoroughgoing specialization is not sound science; nothing is truly understood until nature as a whole is understood and the local part is perceived in its exact status in and connection with that whole. This was one of the major reasons why Greek science was so inherently and inescapably philosophical. The modern conception, arising with Galilei's founding of "the science of local motion," and with Newton's principle of isolation and the attendant emphasis on masses rather than structure, led naturally to the conception of nature as an aggregate of many physical objects; hence, the current notion that scientific knowledge is possible for a person only in a very narrow field, and the attendant corollary that any attempt, such as the philosopher sometimes proposes, to talk about the whole, is idle footless speculation.

This opposition expresses itself in one other distinction: Greek science, except for the atomists, who were repudiated in mathematics, for reasons which we shall show immediately, placed the emphasis on continuity; modern science, on discontinuity. The reason for the Greek point of view is to be found in the discovery of the incommensurable by the Pythagoreans. They and the atomists, like the moderns, began with a discontinuous theory. The attempt was made to build up lines and surfaces and solids out of discontinuous elements or "pebbles." In short, they tried to define the continuous in terms of the discontinuous, and to reduce geometry to arithmetic. This worked beautifully until they came upon the length of the hypotenuse of a right-angled triangle, the other two sides of which are equal. Setting the sides equal to unity the length of the hypotenuse is $\sqrt{2}$. Stated in more concrete terms, this means that any "pebble" or unit of length which goes into the length of either side a definite number of times leaving nothing over, will always leave something over when the hypotenuse is measured. This convinced the Greeks that the continuous will not reduce to the discontinuous and that geometry is more fundamental than arithmetic (Euclid, V). Bk. Modern science, on the other hand, discovered nature to be atomic, reduced geometry to arithmetic by generalizing its theory of number (Dedekind, Cantor), and regarded discontinuity, and the many, as more fundamental than continuity, and the one.

This modern emphasis on entities, fluid forms, atomicity and discontinuity has dominated biological thought. Galilei had no more than developed his physical and mechanical theory of the inorganic universe before Harvey proceeded to apply physical and mechanical conceptions to living creatures in the discovery of the circulation of the blood. Lavoisier revealed the chemical character of respiration and metabolism in living things at the same time that he placed chemistry upon secure foundations with the discovery of the principle of the conservation of mass. Gradually with Liebig and Wöhler, and the vast army of physiologi-

cal chemists, the chemical nature of living creatures has become more and more evident. It is to be noted that this is a distinctly modern emphasis. Chemistry rests upon a discontinuous atomic conception of nature, and atomism in its traditional interpretation involves an emphasis upon entities rather than upon structure and on the constituent elements rather than upon the whole. This attitude of mind has gone all through biology even where no appeal has been made to the chemical nature of the processes or factors considered. Practically a century ago Schleiden and Schwann discovered the cellular nature of plants and animals. Here was the supposedly ultimate biological atom. More recently the emphasis has shifted from the cell to the gene, but even so the emphasis is still on entities.

It is to be noted that this entire development involves the carrying over into biology of a philosophical standpoint which was discovered and clearly formulated first in physics and chemistry. There can be no doubt of its success or validity. There is nothing to date to indicate that the biologist should hesitate to follow the lead which the more mature and exact science of physics gives him.

If this be granted then it is clear that a slight change of emphasis must come into biological theory. For the entire modern standpoint with its emphasis on entities rather than organization, upon discontinuity rather than continuity, upon local systems rather than upon their status in the total field of nature as a whole, has been found in physics to need rather radical and thoroughgoing supplementation. The word supplementation is to be emphasized, for the modern standpoint has not been rejected; it is being merely amended. The amendment is so thoroughgoing, however, as to amount to the placing of the Greek upon an equal footing with the modern standpoint. Moreover, the concepts modified are so primary in the levels of importance and so general and universal in their application that every branch of human activity, and even the very meaning and significance of any fact we observe or experiment we perform are affected.

The elemental and essential fact as it appears in physics can be stated very briefly; atomic physics has had to be supplemented with field physics. The point to be noted is that the particle both conditions and is conditioned by its field. Stated in more general terms this means that continuity as well as discontinuity is ultimate, that nature is both one and many. In short, any local system in part constitutes and is in part constituted in its behavior by nature as a whole (Freundlich, 1933) and the physical field in which it is embedded. This rediscovery of the continuous field, or the one, as a causal factor conditioning the behavior of the constituent particles, or the many, is a return to the Greek standpoint. But the particles also determine the character of the field. This is the modern viewpoint. The reciprocal causal relation between field and particle amounts to a union of both viewpoints. This is the fact which anyone with an eye to first principles can see standing out amid all the complexities and confusions of current discoveries in physics.

But this mere designation of the fact is not enough. We do not possess science until our findings are formulated in terms of clear consistent principles. At this point current scientific and philosophical thought is confronted with a serious difficulty. According to all traditional scientific and philosophical conceptions the Greek and Modern views of science contradict each other. It was precisely because of this contradiction that we had to

reject Plato's and Aristotle's physics, biology, and philosophy in order to accept Galilei's, Newton's, and Darwin's. The difficulty can be put very simply. The modern conception of nature as a discontinuous collection of moving particles makes all order in nature a temporary effect, renders nature as a whole a mere aggregate, and provides no meaning for continuity as a primary factor or for the field as a causal factor. The Greek conception, as formulated, either in mathematics and astronomy by Plato and Eudoxus, or in biology by Aristotle, does justice to the continuity and unity and organization, and to the field character of natural phenomena, at the cost of interpreting nature as a single substance or system and rendering change, atomicity, and the temporal origin of species meaningless. It is clear, therefore, that before the doctrine of reciprocal causal interaction between particle and field can possess meaningful, consistent theoretical formulation a new theory of the first principles of science must be developed. Moreover, this new theory must combine the Greek and Modern conceptions of science which have previously been supposed to be incompatible.

It is essential that the reader sense the necessity of this theoretical formulation before going further. Otherwise the electro-dynamic theory of life proposed in this paper will appear as but a new name for traditional conceptions, and its essential novelty and significance will be missed. This point may be made by referring to an experience which the authors of this paper had when the theory, proposed here, was presented to an experimental anatomist. He replied, "Yes, the field theory of life is reasonable, but what is the field except as it is determined by its physico-chemical constituents?" In this query he gave expression to the fundamental presupposition of traditional modern science, that the field, or nature as a whole, is a mere aggregate of the atomic parts and in no sense a primary causal factor. He was quite right also in suggesting that the field theory of life would be but a new name for old commonplaces were this all that it means. The point is, however, that the theory which we are proposing means more than this. The microscopic physico-chemical constituents do determine the character of the field. No one cognizant of modern physics and physiological chemistry can deny this. But this relation between field and particle is not, as traditional modern scientific theory has assumed, an asymmetrical or one-way relation. The field both determines and is determined by the particle. But to find meaning for the field as, in this partial sense, an ultimate causal factor is the real difficulty. In the traditional modern scientific conception of nature as a collection of particles in motion and physico-chemical interaction, there is no meaning to the field as anything more than a mere aggregate and effect of their compounding; in Newton's physics, given the masses with their inertial and accelerative forces, the gravitational field and the orbits are completely determined. To make sense out of the notion that the field determines the behavior of any local process or constituent within it, it is necessary to modify modern science at its very foundations by revising our theory of first principles to provide meaning for the unity of nature as a causal factor. Without this revision in our most elemental and fundamental conception of nature as conceived by science, all field theories whether in physiology or physics are mere verbiage.

It is easy enough to find meaning for the unity of nature, and for the field as a causal factor providing we return to that

Greek conception of science which makes continuity ultimate, regards nature as one substance, and interprets all plurality as a mere abstraction from the unity. But this is to go to the other extreme and find meaning for the causal efficacy of the field at the cost of denying all determination of the field by the particle. Clearly, modern science will not permit us to do this. It is impossible now to deny the validity of physico-chemical categories. There is the particle as well as the field. It is clear, therefore, that meaning for the field and the unity of nature as a causal factor must be gained without rejecting the primacy of the atomic physico-chemical categories of modern science. The only completely physical theory of the first principles of science proposed to date which accomplishes this is the macroscopic atomic theory developed by one of the authors of this paper (Northrop, 1928, 1931). It retains the kinetic atomic theory of traditional modern science, thereby providing theoretical foundations for the physico-chemical categories which modern investigations have established, and providing meaning for the determination of the field by the particle. To this traditional kinetic atomic theory it adds one macroscopic atom which surrounds and, *solely because of its relatively small fixed finite size*, compresses and congests the microscopic particles, of the whole of nature, of traditional theory, which it contains. Thus a unity of nature as a whole is impressed upon the compounding and aggregating of the microscopic particles to make complex nature one as well as many, a unity as well as an aggregate, a field which in part determines the behavior of each particle and process, as well as a complex continuum, in part constituted by the motion and interaction of the particles. Whether the macroscopic atomic theory will gain confirmation directly by further empirical investigations need not concern us here. Its mere existence as a possible theory is sufficient for our present purposes, since this demonstrates that it is possible to combine the Greek scientific conceptions of nature as a single system with the modern scientific conception of nature as an aggregate of many particles, without contradiction, and thereby gives meaningful formulation to the thesis that the particle in its behavior both determines and is determined by the field in which it is embedded.

Having demonstrated that the doctrine of the reciprocal interaction between field and particle can be given consistent meaningful theoretical formulation, it remains to designate the evidence in both physics and biology which supports it, and the modification in our attitude toward all systems in nature, which its acceptance must entail.

The first conclusive evidence in physics of the necessity of supplementing atomic physics with field physics appeared in the relativity theory. A short survey of certain developments in the history of science will make this clear. Science has always distinguished between two types of structure or relatedness in nature. The one type, most evident in space, is relatively constant through time; the other, evident in the obvious changing relations between things, is subject to change with time. Actually both types of structure or relatedness apply to the physical content of the universe, but Newtonian physics did not view the situation in this light. Instead, it separated the relatively constant spatial structure of physical nature from the physical content and turned the separated structure into an independent entity called absolute space. This space was really a field, but since it permitted matter to move through it without opposition there was little or no meaning to

the statement that the field conditioned the behavior of the particle. A similar separation and reification of the field character of physical nature occurred in the sciences of optics and electricity with the introduction of the ether. The theory of relativity has demonstrated, however, that this entire procedure is mistaken. In doing away with the independent ether, and in merging matter and space and time, Einstein has shown that the approximately constant macroscopic structure of space is the approximately constant macroscopic structure of matter itself. The field is not independent of matter but a very condition for and causal determiner of the behavior of matter. Thus Einstein replaces Newton's three laws of motion with the single law that a body moves in a path which is a geodesic of the space-time of the observer's frame of reference. But the general theory of relativity also prescribes that the distribution of matter determines the character of the metrical field, and thereby the lay of the geodesic. Thus the particle both conditions, and is conditioned by, the metrical field.

These considerations from the verified general theory of relativity are sufficient to indicate that the attempt to conceive of nature entirely in terms of the pluralistic discontinuous microscopic atomic physico-chemical categories of traditonal scientific thought is inadequate. This does not mean that these traditional categories are invalid; they are in fact necessary, as the general theory of relativity indicates when it makes the metrical properties of space dependent upon them and their distribution, but they are nevertheless insufficient. The field also conditions the behavior of the particle.

The second evidence in physics for the theory of the reciprocal determination of particle and field appears in wave mechanics. At this point the relevance of all this for biology can be made more direct and explicit. Biologists have discovered that whatever else living creatures may be they are in a very real and significant sense physico-chemical systems. But chemists and physicists have now conclusively demonstrated that the electro-dynamic theory of nature is more fundamental than the chemical theory. The reduction of the chemical atom to electrons and protons and the development of quantum theory and wave mechanics implies this. Moreover, the recent surprising tendency in wave mechanics is to put the emphasis on the field even to the point at times of attempting to derive the particle from it. This, as Darrow and G. P. Thomson have pointed out (Darrow, 1927; Thomson, 1932), is an error; moreover, quantum physics reveals even new evidences of discontinuity. Nevertheless, the fact still remains that the field as a distinctly causal factor is indispensable.

These established and accepted findings of contemporary physics are sufficient to indicate that the same influence from the mature science of physics, which previously drove biology with Harvey to the mechanical theory of living creatures, and with Lavoisier to the chemical theory of their nature, must now drive us to an electro-dynamic theory of life. Contemporary developments in physics rest upon the discovery of the primacy of electro-dynamic theory over chemical or traditional physical theory.

Moreover, and this is the crucial point, this shift involves much more than a mere shift in terms. Contemporary physics has gone very much further than the mere statement of chemical elements in terms of electrons and protons. The latter advance, while of great importance, still involves the traditional emphasis solely on entities and their motion. The

current shift is much more fundamental than this, for the field as well as the particle is now revealed as a causal factor. Once this point is really grasped our whole attitude towards our scientific knowledge must change. Structure again becomes significant. It is no longer permissible to assume, as traditional modern science has done, that if the constituent chemical components are determined the field and the structure will take care of itself.

The significance of this for biology can be made evident by a brief consideration of its most fundamental and perplexing problem—the problem of organization. It is a commonplace that living creatures, notwithstanding the modification in types in evolution, maintain a certain constancy of structure through continuous changes of material. Aristotle with his doctrine of formal as well as material causes provided a theoretical basis for this fact, but failed to account for the mutability of species. Modern science with its rediscovery of the kinetic atomic theory and its attendant doctrine of the variability of structure with motion, provided meaning for Darwin's discovery, and the physico-chemical nature of life, but at the cost, as Claude Bernard indicated, and as Driesch and J. S. Haldane have emphasized more recently, of failing to do adequate justice to the relative constancy of biological organization. The traditional modern doctrine that the chemical elements completely condition the structure and organization of the organism failed to explain why a certain structural constancy persisted through the chemical flux.

This obvious inadequacy led to the introduction of non-physical factors such as *Driesch's* "entelechy," *Spemann's* "organizer," *Rignano's* "biological energy," *Child's* "physiological gradient," *Weiss's* "biological field," and *Köhler's* "Gestalten," all of which have certain validity as descriptive terms. It now appears, however, that the difficulty may have its basis, not in the failure of any possible physical theory, but in the inadequacy of traditional physical theory. For the chemical view with its emphasis on entities has been demonstrated to reduce to the electro-dynamic view in which the more constant structural guiding contribution of the field is found to supplement the contingent changing relatedness introduced by the motion of the particles.

If this new electro-dynamic theory is correct it follows that biological science must supplement its present emphasis on chemical analysis and on entities with a more serious study, by the experimental determination of potential distribution, of field factors, and structure and organization in itself. It appears also that biology itself suggests the necessity of the particle-field theory.

II. BIOLOGICAL AND NEUROLOGICAL CONSIDERATIONS

The necessity is apparent when an attempt is made to unravel the underlying processes inherent in ontogeny. In spite of the mass of accumulated data concerning the development of the organism in general and of the nervous system in particular, no thoroughly satisfactory explanation has been given of the regulation and control of growth. Description of successive steps of development in a wide variety of forms reveals little of the relationships which exist between the steps or the factors which regulate the passage from one to the other. The very wealth of the accumulated facts tends to obscure the underlying regulation and to defy analysis. It was this difficulty which led Driesch to the repostulation of a "vital force" or entelechy. This brilliant hypothesis has never received its just due. The whole theory is a very adequate

description of an extraordinarily constant control and regulation of growth. Its weakness lay in its assumption of an extra-biological agent incapable of scientific description. The field theories of Spemann, Weiss and Gurwitsch are also valuable attempts at explanation, but like the entelechies of Driesch, scientific analysis is wellnigh impossible.

All embryologists have been impressed at one time or another with one aspect of the problem noted above. Growing systems possess an extraordinary capacity for self-regulation. Some powerful agent seems to be inherent in the system through which the progress of development from stage to stage is coördinated and regulated according to a definite plan. Each and every biological system seems to possess a dynamic "wholeness" the maintenance of whose integrity is a necessity of continued organic existence. Virtually all the theoretical analyses stress this quality but no adequate definition of this dynamic agent or adequate explanation of its working has been offered.

Not only is the regulation in ontogeny an enigma, but we are still almost completely ignorant of the dynamic relationships in living systems. A considerable body of information is available concerning the physical and chemical structure of protoplasm but we know little of the way in which the elements are organized into a dynamic whole. The cytoplasm of a living cell is not a formless agglomeration of chemical substances but is an integrated and coördinated system. It is impossible to conceive of cytoplasm as a haphazard arrangement of molecules. A definite pattern of relationships must exist. We possess a modicum of knowledge of these relationships at any one moment but we have no adequate theory of the mechanism which maintains that pattern throughout the rapidly changing flux in living systems. Study of the situation in the nucleus is somewhat more advanced because of the greater definiteness of the formed elements. We possess fairly clear statements of the physical and to some extent of the chemical components of the nucleus. The dynamic activities of the formed elements, the chromosomes, have been partially unravelled by geneticists. As in cytoplasm however, we lack any adequate hypothesis of the mechanisms involved in chromosomal aggregations or in the splitting and distribution of the component elements. The results of the processes have been widely studied and have provided an important body of information but we still lack understanding as to how the results are accomplished. Here then, as in embryology, we find "pattern of organization" the fundamental problem.

The difficulties suggested above are no less apparent in the analysis of the development of the nervous system. The successive steps have been described by innumerable workers but we lack any rational explanation of the appearance of local regions of growth and differentiation and of the final establishment of nuclear masses and fiber tract pathways. Although Spemann has shown the importance of the dorsal lip of the blastopore as a concomitant of the formation of the nervous system, there is little understanding of the factors involved in this relationship. Moreover, neither fact nor theory has yet made clear the nature of the factors which give this power to the dorsal lip of the blastopore.

Careful consideration of the many facts of which the above is but a suggestive résumé, compels us to look for an hypothesis which will cover not only the dynamics of development but also the pattern of organization of unitary biological systems. The search for such an

hypothesis has intrigued many investigators. As has been shown earlier in this paper, its formulation has been hindered by reliance upon earlier physical theory. With the advent in physics of the field theory of the relationships between particulate matter, the resolution of the biological theory becomes clearer. It is believed that the theory about to be proposed satisfies this condition and if it can be demonstrated, gives the solution to many problems of biology.

The theory is the result of many years of experimental investigation of the mechanisms involved in the development of the nervous system (Cf. Burr, H. S., 1916a, 1916b, 1920, 1924, 1926, 1930, 1932). In these studies it has been shown (Burr, 1932) that an extremely important factor in the organization of the nervous system is the rise and fall of differential growth rates within the wall of the neural tube. Moreover, experimental work confirms the belief that the direction of growth and the end station of differentiating nerve fibers is related to these primary centers of rapid proliferation. Inasmuch as they seem to be potent factors in imparting the fiber pattern to the nervous system, it becomes necessary to inquire into the agents which could act to determine the locus of these areas and to regulate the division rates in them. If this could be settled then it would be possible to formulate an hypothesis as to the origin of pattern in the nervous system. Conceivably this might provide a clue to the origin of pattern in developing organisms and in other living systems.

An increasing body of evidence (Gurwitsch, 1926; Ingvar, 1920; Lund, 1922) indicates that bio-electric phenomena underlie growth as well as many other biological processes. Numerous electrometric studies compel us to believe in the presence of polar and potential differences in living systems. If this is true it follows by definition that electro-dynamic fields are also present. Their existence in the physical world is generally accepted. Moreover, the formed relations of particulate matter is to a considerable degree a function of such fields. Thus the individual characteristics of atomic matter are a result of the interdependence of fields and particles. Pattern in physics, then, is determined by the interplay of electro-dynamic fields and the particular matter therein contained.

It is reasonable to extend this hypothesis into the realm of biology. Potential gradients and polar differences exist in living systems. If this is so, then electro-dynamic fields are also present. The following theory may therefore be formulated. The pattern or organization of any biological system is established by a complex electro-dynamic field, which is in part determined by its atomic physico-chemical components and which in part determines the behavior and orientation of those components. This field is electrical in the physical sense and by its properties it relates the entities of the biological system in a characteristic pattern and is itself in part a result of the existence of those entities. It determines and is determined by the components. More than establishing pattern, it must maintain pattern in the midst of a physico-chemical flux. Therefore, it must regulate and control living things, it must be the mechanism the outcome of whose activity is "wholeness," organization and continuity. The electro-dynamic field then is comparable to the entelechy of Driesch, the embryonic field of Spemann, the biological field of Weiss.

The implication of the above theory for embryology yields a number of interesting points only one of which can be considered here. An intriguing problem in

chordate development is the establishment of a longitudinal axis. This is a very real structural alignment although at early stages in development the cells which are related to it may be toti-potent. Experimental rearrangement of the cellular units does not change the axis although they themselves may have their ultimate fate altered. Caudal cells may become cephalic cells, right cells may become left with little serious interference with the normal processes of growth. Yet in some way the constituent cells of the growing system have their fate determined and their behavior and orientation controlled.

At least two factors in this regulation are familiar. Embryology and genetics have given adequate evidence of the importance of the chromosomes in determining cellular fate. The investigations of Weismann, Driesch, Boveri, Hertwig and many others attest this. The geneticists have confirmed it and we are compelled to believe that the formed elements in the nucleus partly determine the growth and differentiation of cells. But the experimental embryologists have shown that intercellular relationships are no less important. Spemann and his students have demonstrated the dependence of cells on their local environment. The induction or organization hypothesis is an expression of their findings. To genetic constitution, then, there must be added local cellular environment as an important determiner of cell fate and therefore of the organization of the growing systems.

To Driesch, however, we owe the brilliant observation that the fate of any group of cells in an embryo is not only genetically conditioned but is also a function of the position of that group in the whole biological system. The mechanism by which position could determine cellular potencies was explained by Driesch through the assumption of an extra-biological guiding principle, an entelechey. It is at this point that the electro-dynamic field theory proposed above provides a significant explanation of the well recognized facts. In the physical world the nature of an atom is dependent upon the number of entities which comprise it and the field in which they lie, the position of the electron orbits being of fundamental importance. So, on a very much more complex scale in a biological system the fate of any group of cells is determined in part by the position those cells occupy in the electro-dynamic field of the embryo. It is clear that if the above be granted three factors are present in the normal development of an organism. The cells must possess a certain genetic constitution, a certain cellular environment and a certain position in an electro-dynamic field.

This is not the place to extend the application of the theory to many other problems of embryology for another important aspect calls for attention. The pattern of the organization of the molecular and atomic constituents of protoplasm is an even more important problem to biology than the physico-chemical nature of the entities themselves. It is not enough to know the chemical formula of protoplasm. It is of vital importance to understand how the elements are related to each other, how they are gathered together in a single "whole" system. If the electro-dynamic theory is sound the characteristic relationship of the elements of any biological system is a function of the field of the system. If this be true then the great jump from living organic matter to non-living physical matter is no longer inexplicable. The difference between the two is to be found in all probability in more complex fields and more complex molecular structure. Life, then, is not a special creation but an expression

of fundamental law operating in living and non-living matter alike.

The theoretical considerations here presented have led us to the conclusion reached by nearly all other investigators, that pattern or organization is a fundamental characteristic of biological systems, or of physical systems, or of the universe. The electro-dynamic theory provides a working hypothesis for a direct attack upon this problem. If accepted, it opens up a wide field of study based upon electrometric methods. It should be possible, therefore, to determine by objective experiment whether or not such fields exist. In other words, this theory can be put to experimental test. Finally the theory makes it possible to place the investigation of the organization of living systems on the same objective and physical basis as the analysis of their chemical constituents.

It appears, therefore, that an hypothesis of this type is necessary to bring biological theory into line with physical theory. Moreover, biological considerations alone affirm a similar necessity and provide a sufficient amount of data to warrant putting to Nature, by experimental and electrometric methods, the questions which this theory raises. These questions fall naturally into three categories. In the first of these are to be found questions as to the presence and character of potential and polar differences in living organisms. In the second are the questions dealing with the measurement of electrodynamic fields as concomitants of the potential differences. In the third are those questions which are associated with the impact of an altered field in the environment on developing mechanisms. In all probability new technical methods will have to be devised before definite answers can be obtained. Furthermore, if the theory is established, it makes possible the application of the mathematical methods being developed for field and wave physics to biological material, thereby placing the study of biological organization on a mathematical as well as an experimental basis.

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THE ALL-OR-NONE PRINCIPLE AND THE NERVE EFFECTOR SYSTEMS

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THE all-or-none principle states that there is an all-or-none *relation* between the stimulus and the response which it sets up (Bowditch, 1871; Adrian, 1931). As pointed out by Adrian (1914), this all-or-none relation is a necessary consequence of the coexistence of the following three conditions in the excitable structure: a threshold, an absolute refractory period and a conduction of the excited state over the whole structure so that it behaves as a single unit. If any one of the three conditions stated is lacking, the response will not be all-or-none (quantal).

WHAT IS MEANT BY "STIMULUS"?

A great deal of discussion about the validity of the all-or-none principle in different systems would be avoided if the terms stimulus and response were precisely defined. The usual convention is to designate as stimulus the external agent applied by the experimenter and to call a response any active change in the tissue elicited by this agent. Since there are frequently several intermediate steps between the stimulus and the ultimate response, it is obvious that any analysis which disregards these intermediate steps will be incomplete, and therefore fallacious.

Suppose an electric shock is applied to an autonomic nerve supplying a smooth muscle. The electric shock (stimulus) produces in the nerve a local excitatory state, which is passive and which we therefore do not call a response. If this local excitatory state reaches a threshold value a nerve impulse ensues, which is the response of the nerve to the stimulus. This impulse, on reaching the muscle, behaves now as a stimulus and evokes an electric potential (initial potential, Rosenblueth, Leese and Lambert, 1933) and the liberation of a certain amount of a chemical mediator (see Cannon, 1933). We do not know the relations existing between the initial potential and the chemical mediator, but we may assume provisionally that the potential precedes the liberation of the mediator and stimulates the production of the latter (see below). The mediator, a response to the conducted disturbance in the muscle, now combines with the receptive substance and the compound thus formed stimulates the contractile mechanism (Rosenblueth, 1932b), so that a final contractile response ensues.

As pointed out by Adrian (1922), if there is any all-or-none step in such a series, it will necessarily impose an all-or-none relation between a single stimulus and the final response of a single element. An observation establishing such a quantal relation will not give any information as to whether there is more than one all-or-none step, where this quantal step or steps occur, and whether there are any graded processes involved. Direct stimulation of muscle (Pratt and Eisenberger, 1919; Bozler, 1927, 1928 and 1931; etc.) is, therefore, preferable to the stimulation of the nerve supply (Lucas, 1909), when investigating the all-or-none characteristics of the former.

WHAT IS MEANT BY "MUSCLE"?

Even direct stimulation of muscle is not, however, sufficiently discriminating. "Muscle" is a term which belongs to gross anatomy. The microscope reveals not only muscle fibers but a very complex structure in the muscle fiber. Physiologically the striped muscle fiber presents at least two features, a conducting and a contracting system. In smooth muscle there are at least three processes: the production of the mediator (see Cannon, 1933), its combination with the receptive substance (Cannon and Rosenblueth, 1933) and the contraction. A thorough knowledge of the quantal processes in either striped or smooth muscle requires a discrimination between the successive steps as to all-or-none or graded behavior.

Pratt and Eisenberger (*loc. cit.*) found a quantal response of striped muscle to direct electrical stimulation. Graded responses may, however, be obtained, as shown by Fischl and Kahn (1928), Gelfan (1930) and Asmussen (1932). From these conflicting results we should be led to the quite unilluminating conclusion that there may or may not be an all-or-none relation between the electric stimulus and the muscular response. The obscurity disappears, however, when we take account of the intermediate steps, for, as reported by Gelfan and Bishop (1932), the graded responses are obtained when the stimulus skips the conducted disturbance and acts beyond, presumably on the contractile system itself.

The indiscriminate use of the term "stimulus" is confusing when applied only to the first link of a chain of events functionally related. The real stimulus to a given reaction is the event which immediately precedes it and of which the reaction is a direct consequence. Thus, in autonomic effectors the real stimulus for the final specific response implied by the term effector is not the electric shock, nor the nerve impulse, nor the initial potential in the effector, but the compound formed by the combination of the mediator with the receptive substance. Our analysis of the applicability of the all-or-none principle to neuro-effector systems will consist in an examination of the relations between each step and the succeeding one in the series of functionally related phenomena which begin at the peripheral efferent nerve and end with the specific reaction of the effector. The problem, then, is to determine, in view of the evidence available, whether there is a quantal or a graded process at each of the consecutive links in this chain of events, and to ascertain what links are activated by our experimental means of excitation.

THE CHAIN OF EVENTS IN EXCITATION

According to the data available, the following is the sequence of functionally related events which probably occur in the electrical excitation of a neuro-effector system: 1) electric shock → 2) local excitatory state in nerve → 3) nerve impulse (conducted disturbance in nerve) → 4) local excitatory state in neuro-effector junction → 5) conducted disturbance in the effector → 6) liberation of mediator → 7) combination of mediator with receptive substance → 8) specific reaction of the effector (contraction or relaxation of muscle, acceleration or deceleration of the heart, secretion, etc.).

We shall first examine the evidence which leads us to postulate the existence of the links in the above chain of events that are not generally recognized; we shall then consider at what links the chain may be activated by the physiological and by certain experimental stimuli, or blocked by some paralyzing drugs; and we shall

finally point out some of the implications of the views adopted.

The fourth link (4, in the series) is postulated to cover the cases of peripheral summation of nerve impulses. This summation of nerve impulses is known to occur in striped muscle (Lucas, 1917a and b; Bremer and Homès, 1931). It would also occur in autonomic systems if some of them should be "iterative," in the sense of Lapicque and Meyerson (1912). The expression "local excitatory state," used in analogy to the corresponding phenomenon in nerve, is meant to be quite non-committal as to the nature of the process involved. Adrian and Lucas (1912) offered the explanation that a second impulse succeeds in stimulating the muscle, while the first one fails, because the second one appears during the supernormal phase of recovery from the first, and is therefore better conducted. This explanation was based on the idea that decremental conduction occurred at the junctional region (see Adrian, 1920). Adrian (1920) showed, however, that the super-normal phase occurs only at a pH which is improbable in highly buffered physiological systems. Furthermore, conduction with decrement is also quite improbable (Kato, 1924; Davis, Forbes, Brunswick and Hopkins, 1926). We must, therefore, seek for another explanation.

Assuming the membrane theory, since a nerve impulse can reach the muscle and stop without eliciting a conducted disturbance in the muscle, it is obvious that there is a discontinuity between the two polarized interfaces responsible for the conducted disturbances. If the successive nerve impulses are of equal intensity, as is probable, it is reasonable to assume that each one leaves an effect at the junction of the nerve with the muscular polarized interface and that succeeding nerve impulses add their effects to those remaining from the preceding impulses until a threshold is attained and the conducted disturbance of muscle is originated. It is to these additive effects at the neuroeffector junction that we apply the expression local excitatory state.

It is possible that link 5 does not exist in some autonomic effectors. Thus Rosenblueth, Leese and Lambert (1933) failed to find any evidence of an initial potential in the pregnant uterus excited through the hypogastric nerves; and Rosenblueth, Forbes and Lambert (1933) concluded that the potentials recorded from the submaxillary gland were probably correlated with the chemical changes involved in the responses, and not with the excitatory process.

The spike potential of striped muscle is generally recognized to be associated with the process of *conduction* of excitation throughout the muscle fiber. Such a process is superfluous in autonomic systems since the effector cells are small, and the mediator diffuses freely from cell to cell (Rosenblueth and Rioch, 1933). There is no quantal wave of excitation transmitted from cell to cell as in cardiac muscle (Rosenblueth and Rioch, *loc. cit.*). In view of these reasons, it is possible that the initial potential of smooth muscle (Rosenblueth, Leese and Lambert, *loc. cit.*) may not be strictly analogous to the spike potential of the conducted disturbance of striped muscle. Until more evidence is available, however, it is perhaps safer to assume this analogy.

The evidence for the existence of the chemical mediator (link 6) has been obtained from autonomic systems (see Cannon, 1933, for references). We assume, however, that there is probably a chemical mediation in striped muscle likewise, because a chemical theory is the most satisfactory explanation for the phenom-

enon of summation of contraction (Rosenblueth, 1932b), and for peripheral inhibition (see below) such as that which appears in the striped muscle of the claw of arthropods; also because the analogy with what occurs in smooth muscle is legitimate until proof to the contrary is presented; and finally, because no known fact contradicts this hypothesis (Rosenblueth and Rioch, *loc. cit.*).

Link 7 is postulated to account for the relations existing between degree of stimulation (nervous or chemical) and response (Rosenblueth, 1932a and b), and to explain peripheral inhibition (Cannon and Rosenblueth, 1933).

It is probable that some of these steps are skipped in some systems. We indicated above that a conducted disturbance may not exist in some autonomic effectors. In the adrenal medulla the mediator, as shown by Feldberg, Minz and Tsudzimura (1933), is acetylcholine. Since the output of adrenin is a linear function of the frequency of splanchnic stimulation (Rosenblueth, 1932b), it is reasonable to assume that acetylcholine acts here directly on the effector, without any previous combination with a receptive substance—i.e., step 7 is absent in this system. In all other systems studied the responses are hyperbolic, not linear, functions of the frequencies of parasympathetic stimulation (Rosenblueth, 1932b) and of the doses of acetylcholine (Clark, 1926).

Adrenin and acetylcholine act on autonomic systems at link 7, as demonstrated by the lack of initial potentials (Rosenblueth, Leese and Lambert, *loc. cit.*). This is in accord with the fact that they are in all probability identical with the mediators postulated in link 6 for autonomic systems (see Cannon, 1933).

The electric stimulus is capable of activating the conducted disturbances 3 and 5 as befits the now generally accepted idea that the propagation of the conducted disturbance is related to the electric phenomenon which accompanies it. Electricity has also some direct effects on the contractile system of muscle (link 8), both striped and smooth (see Rosenblueth and Cannon, 1934, for references). These effects are, however, very small when compared to the contractions obtained when link 5 is affected. Electricity, on the other hand, probably has no direct effects on the secretory system of glands; certainly this is true if we may take as an example the denervated adrenal medulla, which is electrically inexcitable (Rosenblueth and Cannon, 1934).

Ergotoxine blocks sympathetic excitatory impulses beyond link 7, at the effector system proper itself, since the conducted disturbances in the effectors persist (Rosenblueth, Leese and Lambert, *loc. cit.*), the mediator is still produced (Cannon and Bacq, 1931), and the combination of the mediator and the receptive substance still occurs (Cannon and Rosenblueth, 1933). Atropine probably exerts its paralyzing effects at the same level, since the mediator is likewise still produced (Loewi, 1922).

Curare probably blocks the sequence for striped muscle at link 4, as shown by Claude Bernard (1854). Lapicque (1926) suggested that curare acts by increasing the chronaxie of muscle—i.e., at link 5. Grundfest (1932) and Rushton (1933) have brought forward evidence, however, that the muscular chronaxie is unaffected.

The only two links known to be quantal, whatever the means employed to activate them, are links 3 and 5, the conducted disturbances. The proof of their all-or-none character is complete (see Ritchie, 1932, and Adrian, 1933).

Our lack of knowledge of the relations existing between links 5 and 6 in smooth

muscle (see above) does not permit us to qualify the behavior of the latter with respect to the all-or-none principle.

The evidence presented by Davis and Davis (1932), showing that in striped muscle the tension varies as the magnitude of the spike potential, is in favor, however, of the view that 6 is a graded function of 5.

Link 7 is not a quantal step; it follows the law of mass action (Rosenblueth, 1932a and b). Link 8, finally, is a graded linear function of the concentrations of the compounds formed in link 7 (Rosenblueth, 1932a and b). The effector system proper does not follow, therefore, the all-or-none principle.

CONDUCTION IS QUANTAL; EXCITATION IS GRADED

In so far, then, as it is legitimate to separate conduction from excitation, and the schema and evidence presented justify this separation, conduction is quantal while excitation is graded. Thus adrenin and acetylcholine, which excite without conduction, elicit exclusively graded responses. Any investigation which includes either of the two quantal processes of conduction, 3 and 5, may reveal an all-or-none relation between stimulus and response. Indeed, if one deals with elements (single nerves or effectors) the quantal type of response will invariably appear (Lucas, 1909; Adrian, 1914; Pratt and Eisenberger, 1919; Adrian, 1922; Bozler, 1927, 1928, 1931; etc.). Experiments may be devised, however, which, although including the quantal steps, reveal the graded links. Thus, the results of Rosenblueth and Rioch (*loc. cit.*) do not follow the all-or-none principle. These results are the following: after a large fraction (e.g., 5/6) of the nerve supply to an autonomic effector has been destroyed, the mechanical responses to high frequencies of stimulation (e.g., 20 per second) of the remaining nerves tend to become equal to those obtained by the same high frequencies before the nerve supply was impaired, while the responses to low frequencies (e.g., 1 per second) are considerably decreased. If the mode of excitation of the effector were exclusively all-or-none (i.e., if there were no graded steps) a constant fraction of the original responses would be obtained at any frequency. There is some mechanism in play by which any nerve fiber may influence a large proportion of the elements of the effector, and this mechanism is graded. An adequate explanation is that there occurs a free diffusion of the mediator from cell to cell, unlike what happens in striped muscle.

From the physiological standpoint, the specific reactions of the effectors are usually elicited by quantal nerve impulses, whose number varies temporally or spatially. The interposition of the chemical mediation tends to convert this intermittent, quantal mode of excitation into a continuous, graded process. In autonomic effectors the gradation and continuity are still further emphasized by the free diffusion of the mediator. In effectors supplied by the sympathetic an exclusively graded mode of stimulation occurs when adrenin is secreted into the blood stream.

The free diffusion of the mediator in all autonomic systems and the activation of sympathetic systems by means of adrenin decrease considerably the possibility of spatial localization of the responses in the corresponding effectors. The lack of diffusion in skeletal muscle, on the contrary, favors this localization. This difference in the mode of activation of striped and smooth muscle is in keeping with their functions: precise movement of the former and diffuse action of the latter.

There is some evidence pertinent to the

subject which has not been included in this discussion. Gelfan and Bishop (1933) observed conducted contractures without action potentials on mechanical stimulation of single striped muscle fibers of the retrolingual membrane of the frog. The necessary conclusion is that there is some other possible mechanism of conduction than the known wave of depolarization. It is impossible to decide at present whether this other mechanism has any physiological significance.

A broader generalization, which would include the central nervous system, is desirable. Although a similar schema may serve as a help for the study of the transmission of impulses in the central nervous system, it is premature at present to attempt an inclusive generalization.

Obviously, link 8, the specific reaction of the effector, is in itself a complex process. But this process will be different in different effectors, and elude a general treatment. The schema presented attempts to cover only conduction and excitation. We find these processes complex, but probably fundamentally identical in very different structures.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *1901 East Madison Street, Baltimore, Maryland, U. S. A.*

BRIEF NOTICES

EVOLUTION

THE PHYLOGENY OF ZEA MAYS.

By Paul Weatherwax. American Midland Naturalist, University of Notre Dame, Notre Dame, Ind. 50 cents. 9 x 5⅝; 71; 1935 (paper).

Weatherwax accomplishes two useful things in this booklet. He sets down the botanical facts that are definitely and certainly known about *Zea mays* and closely related plants, and he critically examines the various hypotheses that have been advanced to account for the origin of a species that has such obvious handicaps in the struggle for existence. No one is better qualified than he for both tasks. The morphological data are presented in words and in drawings in clear and concise fashion and his criticisms are both vigorous and fair. He is guarded in his own conclusions:

> It seems to me much more in accord with our general ideas of evolution to picture the forerunner of maize as having separated much earlier from the same stock as the *Andropogonae* and having pursued its own course of evolution in complete isolation from teosinte, arriving ultimately at the combination of characteristics previously listed in our description of the hypothetical wild plant at the time of its adoption by the Indians.

There is a touch of melodrama in his supposition that only the timely discovery of maize by some prehistoric Central American farmer saved the species from extinction. Taken as a whole it is a provocative piece of writing, and it may stimulate someone to find the facts that make a final judgment possible. There is a bibliography but no index.

GENERATION OF THE UNIVERSE AND "DESIGN FOR LIVING."

By Percy A. Campbell. Percy A. Campbell, 16208 Nelaview Rd., East Cleveland, O. $1.50. 7¾ x 5¼; 101; 1934.

A philosophical treatise on life, evolution and the cosmos. The fundamental thesis is stated in the dedication page, "This book is dedicated to that most fundamental of all relativity principles, Hegel's doctrine of the inseparable twinship of being and non-being." From time to time a little theoretical physics, Euclidean geometry, and latest theories on evolution are brought in. The book is readable.

BEFORE THE DAWN OF HISTORY.

By Charles R. Knight. Whittlesey House, McGraw-Hill Book Co., New York. $2.50. 9 x 12; xiii + 119; 1935.

This is a handsome volume which should have great appeal for both the art-lover and the biologist. Mr. Knight's murals of prehistoric subjects are well known to many people and one feels a service has been rendered in assembling so many of them in book form. A brief annotation, scientific in character, supplements the illustrations.

THE SCIENTIFIC BASIS OF EVOLUTION. *Second Edition.*

By Thomas H. Morgan. W. W. Norton and Co., New York. $3.50. 8½ x 5½; 306; 1935.

The first edition of this book was reviewed

in Volume 8, page 101. In the second edition Professor Morgan adds a chapter on "Recent contributions to the theory of evolution," in which he deals with the newer work on the theory of the gene, the inheritance of acquired characters and the origin of species. There is a bibliography of 23 pages and an index.

GENETICS

KREBS UND VERERBUNG.

By Hans R. Schinz and Franz Buschke. Georg Thieme, Leipzig. 21 marks (paper); 23 marks (cloth). 10 x 6⅝; 280; 1935.

The authors present a critical review of much of the recent work on the influence of heredity on cancer in man and in experimental animals. Many workers in the field may not agree with some of their deductions, but nevertheless this book is, it seems to us, one of the best surveys yet available on this still unstabilized subject. Beginning with a brief presentation of the principles of genetics, the authors review the literature on the genetics of spontaneous tumors in laboratory animals, genetics of human tumors, transplanted tumors in animals, and cancers produced by chemical, parasitic or x-ray stimulation. They are careful not to assign to all cancers conclusions obtained for one. Three broad groups are given in which hereditary and environmental factors differ in degree and importance in their production: (1) those almost entirely dependent on genetic factors, as in retinal glioma; (2) those mainly dependent upon exciting stimuli, such as tar cancers; (3) those in which both genetic background and stimuli, very often physiologic, appear to be essential. Most human cancers are assigned to this third and most difficult group.

An extensive bibliography and author and subject indices are provided.

THE GENETICS OF GARDEN PLANTS.

By M. B. Crane and W. J. C. Lawrence. The Macmillan Co., New York. $3.00. 8¾ x 5¾; xvi + 236; 1934.

Mr. Crane and Mr. Lawrence of the John Innes Horticultural Institution have written an excellent textbook for students of horticulture and practical plant breeders. The fundamental principles of cytology and genetics are clearly and succinctly stated. Three chapters 30–40 pages in length are devoted to summaries of recent contributions to the knowledge of cytology and genetics of flowering and ornamental plants, vegetable and salad plants, and fruits; fields in which the authors have done important work. The last third of the book is a discussion of bud-sports and variations, incompatibility, sterility, and the appearance of new forms. There is a glossary, a bibliography, and a good index.

BLOOD GROUPS AND BLOOD TRANSFUSION.

By Alexander S. Wiener. Charles C. Thomas, Springfield, Ill. $4.00. 10 x 6⅝; xiv + 220; 1935.

A synthesis of the more important facts regarding blood groups. The author outlines the principles of iso-agglutination, technique of blood-grouping and blood transfusion together with their clinical applications. In more detail he presents the theories regarding heredity of blood-groups and includes a summary of Mendelian principles and statistical methods. The racial differences observed and the medico-legal applications are also amply discussed. The book is written in very clear style with sufficient references and will be found useful as a compendium of the more recent discoveries.

PRAKTISCHE ÜBUNGEN ZUR VERERBUNGSLEHRE. *Für Studierende, Ärzte und Lehrer. Zweite vermehrte und verbesserte Auflage. Erster Teil: Allgemeine Vererbungslehre.*

By Günther Just. Julius Springer, Berlin. 6 marks (paper); 6.90 marks (cloth). 9½ x 6⅝; vi + 137; 1935.

This excellent outline of laboratory exercises for beginning students of genetics has been greatly enlarged and rewritten to bring it up to date. The problems in biometric analyses have been increased from six to ten, and those on Mendelian experiments from seven to fifteen, whereas the

section on human pedigrees has been omitted from this volume of the work. The bibliography has been extended to include recent work.

DIE GENEALOGISCHEN METHODEN ALS GRUNDLAGE DER MENSCHLICHEN ERB-, RASSE- UND KONSTITUTIONSFORSCHUNG.

By Max Kässbacher. Otto Gmelin, Munich. 1.80 marks (paper); 2.70 marks (cloth). 8¾ x 5¾; 51; 1934.

A short exposition of the methods of collecting and portraying genealogical material. Some material on the racial and biological factors influencing family traits is included. The brochure is adequately illustrated and equipped with a bibliography of four pages.

PRINCIPLES OF GENETICS AND EUGENICS. *A Study of Heredity and Variation in Plants, Animals, and Man.*

By Nathan Fasten. Ginn and Co., Boston. $2.80. 8¼ x 5½; viii + 407; 1935.

The Jukes and the Kallikaks still doing business at the old stand! The straight genetic chapters are quite well done for an elementary text.

GENERAL BIOLOGY

THE PHILOSOPHY OF A BIOLOGIST.

By J. S. Haldane. Oxford University Press, New York. $2.50. 7⅜ x 4¾; xii + 155; 1935.

In this interesting book Professor Haldane gives a succinct summary of his philosophy as it has developed out of his work as a physiologist. This has convinced him that the purely physical interpretation of the universe, however serviceable practically, is inadequate to deal with the integration and coordination which the living world manifests. Moreover when we come to deal with the conscious activities which psychology takes for its province the concept of personality, with its perceptions, motives and actions inextricably interrelated, is essential to any understanding of the subject. But personality implies more than the individual personality.

> Our interest extends into the interests of other personalities, and over a past and future beyond the apparent time limits of individual personality. It includes the striving after right or good conduct, which is far more than an expression of mere individual interest. It also includes the search after truth, which, even though the truth is only partial, has binding authority for all personalities: also the perception and furtherance of beauty, which appeals to all, regardless of their individual interests. We find also that right, truth, and beauty are essentially one. We cannot interpret these features in any other way than that all-embracing personality manifests itself in individual personality, and that in this all-embracing personality is summed up the reality of our experience.

Thus the author leads us by successive steps to a view of the real universe as "a universe of personality, and the manifestations of God."

THE NATURAL HISTORY OF THE HITCHIN REGION.

Edited by Reginald L. Hine. Contributors: E. F. D. Bloom, G. B. Howells, J. E. Little, Ray Palmer, A. H. Foster, F. W. Edwards, W. H. Lane. Hitchin and District Regional Survey Assoc., Hitchin, Hertfordshire. 7s. 6d. net. 9½ x 6½; 256 + 25 plates + 2 folding maps; 1934.

This volume is meant to be a naturalist's guidebook to the region lying within a radius of ten miles of Hitchin, a town about thirty miles north of London. A multitude of naturalists have studied this district, their publications have been numerous and so, for the most part, this volume is not so much a record of new work as it is a discussion of the most noteworthy natural features, an annotated list of local plants and animals, and a bibliography of works dealing with the natural history of the region.

E. F. D. Bloom contributes an excellent article on geology and very neatly indicates the dependence of plant life and of human activities on the physiography of the region. His maps are very helpful and there is an Ordnance Survey map of the Hitchin district in a pocket at the back of the book. He also has a short article on aromatic and medicinal herbs.

The annotated list of the animals of the district is largely the work of Ray Palmer and A. H. Foster, the former treating most of the invertebrates and the latter treating the vertebrates and the Lepidoptera. F. W. Edwards treats the Diptera. J. E. Little's article on botany lays rather more emphasis on local botanists than it does on local plants. W. H. Lane discusses the archeological finds made in the district, from Acheulean flints to relics of the Norman period.

The book is very well illustrated throughout and has an index and bibliographic citations. It is unfortunate that the names of the authorities were not appended to the Latin names of animals and plants.

BIOLOGY FOR EVERYMAN. *In two volumes. By J. Arthur Thomson. Edited by E. L. Holmyard. E. P. Dutton and Co., New York.* $5.00. $7\frac{3}{4}$ x 5; xviii + 1561; 1935.

Thomson's introduction to biology will probably turn out to be the cleverest piece of popular scientific writing of the year. In formal outline it follows the usual arrangement of the standard textbooks, but he seems to have adopted the principle that so far as possible he would include no technical details to which he was not going to refer a second time. His emphasis is on the interrelationships between the several parts of an organism and on the interrelationships that exist between different species under natural conditions. Its chief merit, it seems to us, is that it makes it possible for a reader to get a synoptic view of nature that he might ordinarily lose in a confusion of details. It will not take the place, of course, of the standard textbooks, but it will teach some biology in a thoroughly sound manner to a multitude of people who might not learn it otherwise. The factual content of the two volumes is about the amount a college student would be introduced to in his first two or three biology courses but it is presented in an informal way and with a wealth of apposite anecdote that only an experienced teacher would have at his command. There is an excellent index but the illustrations are poor.

A MANUAL OF DRAWING FOR SCIENCE STUDENTS.

By Justus F. Mueller. Farrar and Rinehart, New York. $1.75. 8 x $5\frac{3}{8}$; xiii + 122; 1935.

Biologists will welcome the appearance of a textbook of drawing that is based on sound technical principles and is concisely and clearly written with their needs in mind.

The first five chapters of the book, and part of the sixth, discuss principles involved in even the most elementary problems of drawing, and hence should be of interest to the general student. The sixth and seventh chapters are designed to meet the needs of advanced students and research workers, who have greater facilities for making drawings, and who must produce work acceptable for publication.

Mueller wisely undertook to explain the reason for each of the general principles and procedures he recommends, an appeal to the prejudices of his readers, and supplemented his words by series of sketches showing the stages in the construction of a number of drawings. His methods, and the order in which he presents them, are based on orthodox art school practice. There are ninety well chosen illustrations and there is a good index.

COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY. *Volume II.*

The Biological Laboratory, Cold Spring Harbor, Long Island, N. Y. $3.35. $10\frac{3}{4}$ x $7\frac{3}{4}$; xii + 284; 1934.

These papers and edited discussions growing out of the second Cold Spring Harbor Symposium deal with the general question of "growth." The papers cover a wide variety of subjects under this general heading dealing with chemical, physical and mathematical aspects of growth; genetic and ontogenetic aspects of growth; growth as exemplified by experimental population studies on yeast, protozoa and *Tribolium*, and growth as influenced by radiation. The papers, quite naturally, form a rather heterogeneous collection of material in which there is little integration of the subject matter. However, many of the reports are certainly valuable and authoritative and the enterprise as a whole seems worthy of praise. The discussions after

each paper frequently bring out suggestive points and also add a personal touch to the volume which is quite novel.

URDEUTSCHLAND. *Deutschlands Naturschutzgebiete in Wort und Bild. Lieferungen 1, 2, 3, 4, 5, 6.*

By Walther Schoenichen. J. Neumann, Neudamm. 2 marks each. $10\frac{3}{4}$ x $8\frac{1}{4}$; Lief. 1, 1–24 + 9 plates; Lief. 2, 25–48 + 9 plates; Lief. 3, 49–72 + 9 plates; Lief. 4, 73–96 + 9 plates; Lief. 5, 97–120 + 9 plates; Lief. 6, 121–144 + 9 plates; 1934–35 (paper).

This beautifully produced work will appear in two volumes of twelve *Lieferungen* each, to be published monthly over a space of two years. It may be said to be part of the Appreciation of Nature in the Vaterland movement, and is intended for persons interested in the conservation of wild life, foresters, school and public libraries, hikers and travel bureaus. The first volume will be confined to geology, the second to plant and animal life. There are abundant beautiful illustrations, each number containing a colored plate (usually a reproduction of an oil painting) and eight full-page photographs, besides smaller photographic reproductions, maps and schematic drawings in the text.

BIOLOGY FOR MEDICAL STUDENTS.

By C. C. Hentschel and W. R. Ivimey Cook. Longmans, Green and Co., New York. $7.00. $8\frac{1}{2}$ x $5\frac{1}{2}$; xii + 618; 1932.

This book is intended as a text for premedical students. It contains examples from zoology and botany needed to illustrate fundamental principles. Since the future of the student is constantly kept in mind such matters as pathogenic protozoa and the physiology of endocrine glands in relation to health and disease are mentioned. A whole chapter is devoted to the tape worm (*Taenia*). The book is well written, and has all of the necessary elements needed for a good biological foundation.

APERÇUS TOUCHANT LES OISEAUX, LES INSECTES ET LES PLANTES. (*Trois Mondes d'une Vie Intense Autour de Nous*).

By A. Guéniot. J.-B. Baillière et Fils, Paris. 20 francs. $7\frac{1}{2}$ x $4\frac{3}{4}$; iii + 224; 1934 (paper).

These three little essays on birds, insects and plants were written after Doctor Guéniot passed his eighty-fifth birthday (he is now 102) and after he had retired from medical practice. One of his motives in writing them was to prove that old age does not necessarily mean an ignominious and idle retirement. The essays take the form of field notes on such animals and plants as he kept under observation and are intended, as he says, for children and old people. There are no illustrations and there is no index.

BIOLOGY.

By Frederick L. Fitzpatrick and Ralph E. Horton. Houghton Mifflin Co., Boston. $1.76. $7\frac{1}{2}$ x $5\frac{3}{8}$; xiv + 611 + xlv; 1935.

A high school text in biology is here presented, designed to teach understanding of the basic principles of the living world. It is put together and written in an interesting and straight-forward manner without the interjection of the absurd and artificial devices to amuse and stimulate interest that have unfortunately characterized some of the recent biology texts. It appeals to one as a scientific book simplified and condensed to fit the capabilities of high school pupils.

BIOLOGICAL MOVIE BOOKLETS. *Vol. I, Normal Cell Division. Vol. II, Maturation of Sperm. Vol. VI, Fertilization.*

By Clyde E. Keeler. American Genetic Association, Washington. Set $1.50 (Separately: Vol. I, 50 cents; Vol. II, 60 cents; Vol. VI, 70 cents.) $1\frac{3}{4}$ x $2\frac{1}{2}$; pages unnumbered; 1935.

These movies are amusing and instructive, though it is unfortunate that *Ascaris* is chosen to illustrate normal cell division, since the behavior in all parts is not always typical. There is a brief introduction to each booklet, explaining the contents, but

without textbook preparation the student will not learn a great deal.

LA FÉCONDATION *chez les Animaux et chez les Végétaux.*

By Henri Coupin. J.-B. Baillière et Fils, Paris. 22 francs. 8¼ x 5¼; 203; 1934 (paper).

A very good discussion of the phenomenon of fertilization in the plant and animal kingdoms. The book is liberally illustrated and has an index. It is one of the *Actualités Scientifiques et Industrielles* series.

HUMAN BIOLOGY

THE RESTRICTIVE LAW OF POPULATION. *Imperial College of Science and Technology, Huxley Memorial Lecture, 1934.*

By Johan Hjort. The Macmillan Co., New York. 50 cents. 8½ x 5⅝; 46; 1934 (paper).

Professor Hjort's analysis of the population problem grounds itself fundamentally upon two propositions: (1) that the logistic curve (which he calls the "sigmoid curve") accurately and very generally describes the growth of populations of living organisms, and (2) that Newton's law of motion applies to biological phenomena when stated in the following form:

"Any given historical equilibrium will remain as such or in an incipient state of change, unless the action of forces in this environment alters this condition of things."

His discussion of the world's present difficulties is sound and shrewd:

> This comprehension of the structure of society and of the many and various forms of occupation, all at different stages on the curve of growth, furnishes, perhaps, the clearest picture of the social mentality and of the social organization which has created our European civilization. Europe is an edifice founded and built up on the intelligence of millions of people —on their work and the ingenious use they have made of a thousand possibilities. The multifarious little undertakings created in this way occupy, at any given time, very different stages in the evolution of human occupations. This in itself makes it impossible for them all to offer their employees the same equal conditions of life at the same time.
>
> As a growing population approaches its maximum height and further extension of the environment seems to be excluded, the whole foundation of society seems to become more unstable, so that a process of inner dissolution (struggle for existence) sets in, which often causes the foundation to collapse in sudden ruin.
>
> The divided state, the struggle for existence, war, are *symptoms* of over-population; they are not *remedies* for over-population. *The object of society is, if possible, to prevent over-population from occurring. If over-population exists, the proper remedy is to limit the divided state.* These words enshrine the social philosophy of biology. War destroys the wealth, the organizations, the liberty in the environment of populations, and therefore creates over-population in relation to the reduced environment. War creates an aftermath of experiments intended to mitigate the suffering which is part of the disease created by war; and these remedies often prove worse than the disease itself because they generally prevent the national and international division of labour and nevertheless are considered and applied as a means of creating new wealth for the nation. In reality the purpose of these means is to maintain a maximum population in the reduced environment, and experience always shows that this can only be done by lowering the general standard of life.

All serious students of population will do well to read and ponder over this pamphlet by a distinguished biologist.

THE ESSENTIAL FACTORS OF SOCIAL EVOLUTION.

By Thomas N. Carver. Harvard University Press, Cambridge. $5.00. 8½ x 5¾; xi + 564; 1935.

This volume by a distinguished economist represents, according to his own statement, a life-long interest that he had hoped would ultimately jell into a "monumental work on the general subject of Social Evolution." In the end, however, he concluded that this contemplated treatise was beyond his powers, and so produced the present volume, which he regards as a compromise between his "ambition and his ability."

The result is an interesting, useful, and, particularly to the biologist, a refreshing work. For Prof. Carver's viewpoint and approach throughout is much more intelligently biological than most sociologists seem able to achieve, or even to understand. He stresses survival value as a major element in the evolutionary process, and interprets social evolution in terms of variation and selection. These phenomena as observed in human social groups

are regarded as in direct continuation of the corresponding phenomena among individuals in biological evolution, with the result that in the production of human societal relationships variation and selection among social groups are additional factors added to the strictly biological elements in the picture. The relationship of this point of view to that of emergent evolution, as developed particularly by Wheeler, is evident.

The book is abundantly documented, readably presented, and well indexed. The best thing about it is its good sense. We have space for illustrations of the point only by one quotation. Discussing the ancient problem of environment and heredity Professor Carver says (p. 403):

> One of the great facts of human ecology is that men mold their environment almost as much as the environment molds them. Nor is the molding of the environment confined to the physical side. Men create for themselves a social environment which is quite as artificial or man-made as the new physical environment which they build around themselves. One weakness no environmentalist has yet overcome. No one is able to say what a good environment is like, because no environment is good for everybody. Biologists have found out a few things about heredity; sociologists have found out very little, if anything, about the way any given environment affects character. That which is a good environment for one person is a bad environment for another. The impressions one individual receives from a given set of circumstances are different from those which another person receives.

Altogether we strongly recommend this book to students of human biology.

AN INTRODUCTION TO CULTURAL ANTHROPOLOGY.

By Robert H. Lowie. Farrar and Rinehart, New York. $3.50. 8¼ x 5¼; xiii + 365; 1934.

Professor Lowie's experience as a teacher has shown him "that most students of cultural anthropology and other social sciences are very slow in acquiring an elementary knowledge of culture history, and that many fail to acquire the relevant facts and concepts even years after they have launched on a professional career as anthropologists." To remedy this deficiency is the object of this excellent book, which is arranged under the following chapter headings: Introduction: culture, race and progress; hunting, fishing, gathering; farming; domestic animals; fire, cooking and meals; dress and ornament; houses and settlements; handicrafts; trade and transportation; amusements; art; war; marriage and the family; the clan; rank, etiquette and property; government and law; religion and magic; knowledge and science. In dealing with these topics the objective has been "to stress the simplest tribes, such as the Fuegians and Australians, and, on the other hand, to link the culture of illiterate peoples with the higher civilizations, past and present."

Although this is not a polemic, like Radin's *The Racial Myth*, against attempts to explain culture in terms of race, the racialists will get very little nourishment out of it. "Since biological change occurs slowly and cultural changes occur in every generation, it is futile to try to explain the fleeting phenomena of culture by a racial constant. We can often explain them—in terms of contact with other peoples, of individual genius, of geography—but not by *racial* differences."

A bibliography of 13 pages, an index and maps showing the location of the cultures discussed are provided.

LEXICAL EVIDENCE FROM FOLK EPIGRAPHY IN WESTERN NORTH AMERICA: *a Glossarial Study of the Low Element in the English Vocabulary.*

By Allen W. Read. Paris (Privately printed). 9 x 5¾; 83; 1935.

Anthropologists, psychologists and students of human biology generally will find in this small volume a record, of permanent historical value, of the current American fashions in obscene inscriptions. It is quite evidently an extremely ancient urge that leads human beings to adorn with obscene drawings and written sentiments the places set apart for the reception of digestive and excretory waste products. The author of this treatise, a distinguished philologist and Research Associate in English in the University of Chicago, has brought together a substantial and probably fairly complete (particularly for the Middle and Far West) collection of such inscriptions, and discussed them thoroughly and learnedly from the viewpoint

of comparative linguistics, history and ethnology. The results are of great interest to the student of folkways. One of the strangest of these results, all things considered, is the extraordinarily slight change there has been in the sentiments expressed and in the form of their expression since this type of folk epigraphy began, which probably means when writing began. Mr. Read quotes a number of examples from the *Corpus Inscriptionum Latinarum* for comparison with those of the present day, and then goes on to say (p. 22): "So close is the parallelism both in spirit and in form between these Latin epigraphs and the ones found in western North America that clearly the Americans are merely carrying on the classical tradition."

Obviously this book cannot be freely distributed under our laws. Its circulation is restricted to "students of linguistics, folk-lore, abnormal psychology, and allied branches of the social sciences," and only a very limited edition has been printed.

SPIDER WOMAN. *A Story of Navajo Weavers and Chanters.*

By Gladys A. Reichard. The Macmillan Co., New York. $3.50. 8½ x 5¾; xii + 287 + 9 plates; 1934.

The author, a young professor at Barnard College, spent several summers among the Navajo, the outstanding weavers of the Western hemisphere, endeavoring to master the complicated art of weaving. The book is written in a pleasant narrative style, and while largely concerned with her own struggles with carding and spinning, handling looms, wools, batters and combs, through it all runs a story of Indian weavers and chanters, Indian character and customs. Among the latter of particular interest are the chants and sand paintings, of which the author says:

> The chants which I think of as charms include singing, administration of herbal medicine, and application of sacred objects to the body. Among the most sacred are the sand-paintings, made at particular times during the chant, by artists allowing colored sand to sift through their fingers in the most incredible and regular manner. The result is an astonishing composition of symbolical figures in the softest shades of black, blue, yellow, white, red and pink on a pale tan background. The artists themselves need skill, but they need not know the pictures. This is the duty of the chanter who directs them. The art, a beautiful and unusual one, is evanescent. Paintings which take hours to make are, by the rules of the chant, ruined in twenty minutes, removed in less than half an hour after their completion. For these reasons there is considerable interest on the part of whites to preserve this transitory art [by executing the paintings on paper with tempera, and weaving the designs into blankets].

The book is rather too sketchy to be much of a contribution to ethnology or to the subject of historic fabrics. It is well illustrated with very good photographs.

THE ROCK-ENGRAVINGS OF GRIQUALAND WEST AND BECHUANALAND, SOUTH AFRICA. *By M. Wilman. Alexander McGregor Memorial Museum, Kimberley; Deighton Bell and Co., Cambridge.* 25 shillings net. 12½ x 9¾; xii + 78 + 70 plates and folding map; 1933.

This beautifully printed quarto by Miss Wilman, who is Keeper of the Kimberley Museum, records the results of an extensive, though not complete, survey of the strange rock engravings of South Africa. A high standard of scholarship is maintained throughout the report, which opens with a bibliographic section in which the prior literature on these engravings is critically reviewed and digested.

The engravings are of animals, men, plants, geometrical designs, and footprints of men and animals of various sorts. They are made either as incised lines on the surface of the stone, or as stippled ("pecked") outlines. No one knows with what tools they were made—Miss Wilman thinks probably a diamond, others think quartz or chalcedony flakes. They are probably older than any but the oldest of the rock paintings in the same region. Miss Wilman attempts to specify their age no more precisely than "many centuries" for the oldest engravings. Artistically many of them are charming, and indicate a high talent.

The report is copiously and intelligently illustrated with some 70 photogravure plates, 16 text figures and a detail map showing the location of the sites. There is a bibliography of seven double-column pages, and an adequate index.

While this cannot be regarded as an

epoch-making contribution to ethnology, it is a sound, careful, thorough objective record of fast disappearing artefacts of a primitive civilization and as such of great value. The Royal Society of South Africa and the Carnegie Corporation of New York made no mistake in financially aiding this work.

THE POPULATION PROBLEM IN INDIA. *A Census Study.*

By P. K. Wattal. Bennett, Coleman and Co., Bombay. Rs. 3–8. 7¼ x 5; xii + 185; 1934.

Brief and unpretentious as it is, this book is one of the most important treatises on population questions in recent years, in our considered opinion. It is an enlarged and completely rewritten edition of a work that first appeared in 1916. The author is a competent statistician, fellow of both Royal Statistical and the Royal Economics Societies. He evidently knows his India thoroughly.

With admirable terseness, absence of sentimentality and moral judgments, Mr. Wattal exposes realistically the actual population situation in India, documenting the position at every step from official census figures. On the basis of his analysis of the actualities, which in sum are pretty shocking, he proceeds to suggest sensible steps that might be taken for their amelioration. These include reduction of the death-rate by more effective public health measures; reduction of the birth rate through birth control; a strenuous campaign for widow re-marriage; extension of the Sarda Act (against infant and child marriages); eugenic marriage restrictions.

Writers of the western world on population love to talk about India, mostly without taking pains to inform themselves as to the realities. We cannot too strongly recommend this little book as a healthy corrective to a good deal of misinformation and nonsense now current. It is a fine piece of work.

FIFTY YEARS OF MEDICINE AND SURGERY. *An Autobiographical Sketch. With special reference to the organization and administration of Surgery, Gynecology and Obstetrics, the Clinical Congress, the American College of Surgeons, the Gorgas Memorial Institute, and the participation of the medical profession in the World War. Based on personal diary, professional writings, and digest of professional activities during fifty years. Prepared in narrative form for the lay public and the medical profession.*

By Franklin H. Martin. Surgical Publishing Co., Chicago. Privately published; not offered for sale. 8¼ x 5½; xxvii + 449 + 21 plates; 1934.

This is an interesting chronicle of a man who started practicing medicine in 1880 before Sir Joseph Lister revolutionized surgery with his idea of antisepsis. The author was among the first of American surgeons to put Lister's theories into actual practice in the operating room. In the years he practiced he contributed much to modern medicine and surgery. It was he who conceived and developed the journal *Surgery, Obstetrics and Gynecology*. He also organized the American College of Surgeons.

Doctor Martin, in the course of his long life as a practitioner, teacher and experimentalist, met many of the outstanding physicians and surgeons of this and other countries; some of his contacts with these people are related in his book. This volume will be enjoyed by the admirers and friends of F. H. Martin.

HANDEDNESS, *Right and Left.*

By Ira S. Wile. Lothrop, Lee and Shepard Co., Boston. $2.75. 8¼ x 5½; xiii + 439; 1934.

A comprehensive survey of a subject which is now recognized as an important field by psychologists and students of behavior. The author has delved extensively into the history of the use of the right and left hands. Indeed he carries his studies back to hand preferences in primitive man and even includes a section on heliotropism and heliocentrism. Other subjects which are discussed are philology and hands, causation of dominant handedness, magic and hand values and religion and hand symbolism. In the final section the

author urges that natural handedness should be fostered and conserved. "Handedness as a biological function is one means of releasing the energy of the total personality. The social regulation of handedness reduces energy efficiency. The whole being is most harmonious when its basic unity is respected in terms of structure and function" and "The conversion from right-handedness to left-handedness is not common, but it is, none the less, fraught with distinct hazards. The conversion from left-handedness to right-handedness is too commonly practiced and it frequently involves very definite difficulties which are expressed in the forms of seemingly trifling, but frequently severe, disorders of behavior. Society often pays a high price for its folly."

The volume contains a lengthy literature list and an author and subject index.

HELL-HOLE OF CREATION. *The Exploration of Abyssinian Danakil.*

By L. M. Nesbitt. Alfred A. Knopf, New York. $3.75. 8½ x 5¾; xi + 380 + viii + 16 plates and folding map; 1935.

The story goes that three times expeditions were launched to explore the Danakil territory which lies along the Red Sea in Eritrea. Each of the expeditions met with disaster and none of the European members ever lived to tell the tale. The fourth expedition "got through" as is reported in much detail in the present book by author Nesbitt. Accounts are given of the vicissitudes of the journey itself; word pictures of native faunas and floras, and notes on the mores and folkways of the native inhabitants.

On the whole the book is interesting and it undoubtedly adds many data of general anthropological interest to our knowledge of Africa. Photographs scattered throughout the pages are appealing and increase the value of the work. The reviewer felt that the book was too long and set forth some events which could have been profitably condensed—an opinion which may not be shared by other readers.

L'INDIVIDUALITÉ.

Exposés by Maurice Caullery, C. Bouglé, Pierre Janet, J. Piaget, Lucien Febvre. Félix Alcan, Paris. 15 francs. 8 x 6; iii + 157; 1933.

The *Semaine Internationale de Synthèse* is an annual course of lectures and discussions in which some topic is treated from the viewpoint of various sciences. In the study of the origins of society which was treated in 1930 it became evident that this in turn involved the problem of the relation between society and the individual. In order to be sufficiently *gründlich*, this treatment of individuality begins with a lecture on the principal aspects of individuality in organisms, by Maurice Caullery. In biology, he points out, the word "individuality" is used in two senses: that of unity and that of uniqueness. The former consists in a concentration of elements, a synthesis, the latter results from the diversity of the concentrated elements. Janet treats individuality in psychology; Bouglé, Piaget and Febvre individuality and history, while from a discussion on the individual and society the conclusion emerged that "individuality is that effort of synthesis by which the diverse becomes unified and organized, by which being tends to the greatest possible existence, by which it strives to realize the maximum of being, to employ a favorite expression of Leibniz."

THE CRIPPLED AND THE DISABLED. *Rehabilitation of the Physically Handicapped in the United States.*

By Henry H. Kessler. Columbia University Press, New York. $4.00. 9 x 6; xiii + 337; 1935.

This excellent survey of the needs of the disabled and the extent to which these needs are met by practice and intent is a useful handbook for social workers and legislators. As a group of vocationally maladjusted persons, the disabled are divided for convenience into the child cripple, the industrially disabled, the military disabled, the chronically disabled, the blind, deaf and dumb. Specific and general legislation in the different states is reviewed. For comparative purposes,

some foreign legislation is included. In chapter 23 the author summarizes his findings and gives his conclusions. He believes "that potentially all the needs of the crippled and disabled can be met without resort to evolutionary changes in our social philosophy." In a series of appendixes are given (a) Compensation provisions for second major injuries in those states not having second-injury funds, (b) Summary of vocational rehabilitation legislation by states, and (c) legislation for the blind. The volume concludes with an extensive bibliography and a list of official and semi-official publications and an index.

ROBERTY. *Le Positivisme Russe et la Fondation de la Sociologie.*
By René Verrier. Félix Alcan, Paris. 18 francs. 9 x 5½; 233 + 7 plates; 1934 (paper).

A short biography of Eugene de Roberty, which gives in chronological order the evolution of his ideas. This Russian sociologist belongs to that group of students of social phenomena who discuss ideas but seldom investigate facts. A disciple of Comte and Littré, his sociological writings reveal the common preoccupation of most of his contemporaries as to whether sociology is a "major" or "minor" science, the difference between unknown and unknowable, etc. The nucleus of Roberty's ideas is that the biological being is the result of a long process of adaptation to the environment. The conscience of this bio-individual is derived from a first psychophysical interaction and is the realization of sociality. The conscience of the collectivity arises from a superimposition of individual consciences, their similarities reinforced, their differences eliminated.

The author of this biography is very sympathetic to this philosophy and regards Roberty as one of the great founders of sociology.

EDUCATION OF THE FOUNDING FATHERS OF THE REPUBLIC. *Scholasticism in the Colonial Colleges. A Neglected Chapter in the History of American Education.*
By James J. Walsh. Fordham University Press, New York. $3.50. 9⅜ x 6¼; xii + 377; 1935.

Doctor Walsh has shown definitely that Scholasticism continued to be the mode of teaching in certain of the American colleges until the nineteenth century. He does this by following the broadsheets issued at commencement time showing the subject to be defended by the candidates for degrees. The subject matter and in some cases even the wording of these theses had a decided Scholastic flavor from the first commencement of Harvard through 1810. The first chapter gives an interesting general account of education in the early days of the American colleges. The next seven chapters discuss in more detail the situation of the first seven colleges established, especially as regards the commencement theses.

This is a very valuable book for people interested in the history of education and also for the student of the colonial period.

MEDICAL TACTICS AND LOGISTICS.
By Gustavus M. Blech and Charles Lynch. Charles C. Thomas, Springfield, Ill. $4.00. 9 x 6; xiv + 205 + 4 folding maps; 1934.

Colonels Blech and Lynch are convinced that the next war in which this country engages will be a war of maneuver quite unlike the World War. Their book is mainly an exposition of the classical principles of war presented in simple language and elaborately illustrated by examples with the object of instructing medical men how to adapt their activities to the needs of rapidly moving bodies of troops. About a hundred pages are devoted to detailed description and critical analysis of an imaginary campaign between two armies maneuvering near Gettysburg, Pennsylvania. Excellent topographical maps of the region are provided. If any of our readers are curious to know how hypothetical wounded men are treated in a sham battle this book will enlighten them. The organization of the medical service is summarized and the functions of various officers are defined. There is a glossary, bibliography, and an index.

LIVING WITH THE WEATHER.

By Clarence A. Mills. Clarence A. Mills, University of Cincinnati. $1.50. $7\frac{3}{8} \times 4\frac{7}{8}$; viii + 206; 1934.

Doctor Mills discusses the effects of weather and climate on man. He states that wide variations within an optimal range result in greater energy. He follows Huntington, but goes much further in that he attributes business cycles and our crime wave to the extreme variability of the North American climate. This, he claims, is also responsible for the high tension of our life and therefore indirectly for our immoderate use of stimulants. He advocates greater use of air conditioning to offset the debilitating effect of the moist heat of the tropics.

There are many interesting and valuable suggestions in this book, but it is our opinion that the author has permitted himself to be carried away by his enthusiasm to a certain extent.

KRANKHEIT UND TOD IM SCHICKSAL BEDEUTENDER MENSCHEN.

By Adolf Braun. Ferdinand Enke, Stuttgart. 3.60 marks (paper); 4.80 marks (cloth). 9 x 6; iii + 104; 1934.

Introduced by a short section on the influence of physical constitution on the choice of and capacity for work and outlook on life of various types of geniuses, this is a list, with some biographical matter, of great men in various fields and the causes of their death. In some cases the causes, or at least contributing factors, here given are not those popularly known. The causes in the order given in the book are: old age; apoplexy; violent deaths; cancer; tuberculosis; syphilis; mental diseases; drunkenness and criminality; chronic diseases; acute diseases. There is an index of names and diseases.

VOLLBLUTNEGER UND HALBZWERGE. *Forschungen unter Waldnegern und Halbpygmäen am Ituri in Belgisch-Kongo.*

By Paul Schebesta. Anton Pustet, Salzburg. 8.50 marks (paper); 9.80 marks (cloth). 9 x 6; 271 + 48 plates; 1934.

An interesting account of two years' travel in those parts of equatorial Belgian Congo inhabited by the pygmies. The material in this book is confined, however, more to the Bantu tribes among whom the pygmies live in a more or less biocenotic relationship, the pygmies having been treated more thoroughly by the author in another book, *Bambuti*. The physical characteristics, customs, beliefs and history as far as it is known, of the various tribes are described separately and in detail. In only two cases here discussed, namely the Batwa in Ruanda and the Bachwa, has intermarriage between the Bantus and the pygmies, presumably at some remote time in the past, given rise to races of half-dwarfs. The book is abundantly illustrated with excellent photographs and an index is provided.

THE SOUTH AFRICANS. *New Edition, rewritten and greatly enlarged.*

By Sarah G. Millin. Constable and Co., London. 7s.6d. net. $7\frac{3}{4} \times 5$; x + 332; 1934.

This book first appeared in 1926 and was later reprinted several times. So rapidly, however, has South Africa changed politically, economically and racially within the last eight years that Mrs. Millin has entirely recast and enlarged her interesting volume. She deals with

the racial position of English, Jews, and Asiatics in South Africa; with the Union's new Status Act and the struggle over its adherence to the British Empire; with the rise of the Dutch to power and their relations with the British; with the effects of Nazi propaganda on various elements of the population; with the strange preliminaries of the Smuts-Hertzog Coalition; with the abandonment by South Africa of the Gold Standard, with the results of enquiries in the Poor White and Native questions.

The volume is well indexed.

MEXICO EN CIFRAS (*Atlas Estadistico*) 1934.

Secretaria de la Economia National; Direccion General de Estadistica, Mexico, D. F. $12\frac{1}{4} \times 17\frac{1}{2}$; 180; 1934.

This statistical atlas of Mexico is extremely well done in respect of both planning and execution. The Director General of Statistics, Ramon Beteta, under

whose direction it was prepared, merits great praise for so fine an accomplishment. The work is divided into ten sections dealing successively with: Geophysics, population, education, agriculture, industries, minimum wages, communication and transport, foreign commerce, money and banking, and public finance. Each right hand page is filled by a graph or map (or series of such) while the facing left-hand page carries the explanatory text. The graphs are executed with much artistic skill. Altogether this is an excellent reference source.

THE VICOMTE IN THE KITCHENETTE. *Being the Art of Cooking within restricted space, limited time and reduced income; with the manner how to make easy, dainty, and tasty Dishes; all kinds of inexpensive and rapidly made Novelties; together with a Glossary of Cooking Terms; with finally much advice to those about to set up small house.*

By Vicomte de Mauduit. Stanley Nott, London. 3s. 6d. $7\frac{1}{4}$ x $4\frac{3}{4}$; 146; 1934.

The Vicomte writes smartly about cooking, this time in the limited environment of the ultra-modern apartment, where what does duty for kitchen is not big enough even to *feed* a cat in and do anything else at the same time, let alone swing it. Mary Shepard's drawings that illustrate the book are even smarter than Mauduit's writings.

There are some good recipes in this little volume, along with a somewhat too heavy seasoning of trite banalities. We form the impression that, apart from the occasional novel and really seductive recipe, it will be found *really* useful only by the callowest newly-wed who does not know how successfully to boil a potato.

ALASKA NATIVES. *A Survey of Their Sociological and Educational Status.*

By H. Dewey Anderson and Walter C. Eels. Made under the Auspices of The School of Education of Stanford University at the Request of the United States Office of Education. Stanford University Press, Stanford University, Calif. $5.00. $10\frac{3}{4}$ x 8; xvi + 472 + folding map; 1935.

This investigation, financed by a grant from the Carnegie Corporation, was made at the request of the United States Office of Education and was supervised by the School of Education of Stanford University. It is divided into two parts. The first deals with the ethnology of the native Alaskans and their present social structure, the second with their education. The survey is by far the most comprehensive that has ever been made on these people and is an important book for all who are interested in them. The volume is extensively illustrated and documented, data are arranged in 177 tables and 100 figures, additional material is contained in a group of appendices and there is a detailed index.

THE CHINESE MEDICAL JOURNAL, *Vol. 48, No. 12. Davidson Black Memorial Anatomy and Anthropology Number.*

Published by the Chinese Medical Association. Peiping Union Medical College, Peiping. Mex. $1.50, G $0.60, or 2s. 6d. 10 x 7; 158; 1934 (paper).

Three Forewords open this memorial in honor of a great anthropologist, whose early death was the greatest loss which that science has suffered in a generation. The first Foreword is a brief introductory statement by Dr. Fortuyn. Then follows a bibliography of Black's writings, in turn followed by a reprint of the introductory paragraphs of Dr. Black's Croonian Lecture giving the history of the discovery of the Choukoutien site of *Sinanthropus pekinensis*. The remainder of the number is devoted to eleven papers on anatomical and anthropological subjects contributed by old colleagues and students. The inspiration of Black's leadership is evident in each one of them.

MAHAN-JO-DARO. *One of the Most Ancient Sites of the East which has Aroused World-Wide Interest.*

By Bherumal Mahirchand. Bherumal Mahirchand, D. J. Sind College, Karachi, Bombay, India. Rs. 1.4. $7\frac{5}{8}$ x $4\frac{3}{4}$; iv + 93; 1933.

Until a few years ago little was known of the pre-Aryan culture of India. How-

ever, the excavations at Mahan-jo-Daro and Harappa have shown that, in the words of Sir John Marshall, "five thousand years ago, before ever the Aryans were heard of, the Panjab and Sind, if no other parts of India as well, were enjoying an advanced and singularly uniform civilization of their own, closely akin but in some respects even superior to that of contemporary Mesopotamia and Egypt." Mr. Mahirchand bases his book not only on Marshall's authoritative account of his excavations, *Mohenjo-daro and the Indus Civilization*, but on articles of varying reliability published in newspapers and magazines.

GUIDING YOUR CHILD THROUGH THE FORMATIVE YEARS. *From Birth to the Age of Five.*

By Winifred de Kok. Emerson Books, New York. $2.00. $7\frac{1}{4}$ x $4\frac{7}{8}$; 191; 1935.

A practical handbook for mothers and fathers on the psychology of the young child. Information is simply given about such matters as play, tantrums, fears and fancies, sex education, etc. The point of view of the child is admirably stressed in discussing his problems. A useful book for young parents.

BIOLOGICAL POLITICS. *An Aid to Clear Thinking.*

By F. William Inman. William Wood and Co., Baltimore; John Wright and Sons, Bristol. $3.00 (U. S. A.); 7s. 6d. net (Great Britain). $7\frac{1}{4}$ x $4\frac{3}{4}$; xi + 258; 1935.

The author, a eugenist of the more radical type and an outspoken believer in Nordic superiority, gives his opinions on various and sundry aspects of heredity and its relation to social evolution. There is very little originality but the book makes amusing reading.

IDEALE KÖRPERFORM UND ERNÄHRUNG. *Zugleich eine Anleitung zu zweckmässiger Ernährung.*

By Carl E. Hartmann. Otto Gmelin, Munich. 2.70 marks (paper); 3.75 marks (cloth). $9\frac{3}{4}$ x $6\frac{3}{8}$; 111; 1934.

After a brief introduction on human constitutional types, the author discusses the influence of exercise and various foods in the attainment of an ideal figure. A table of the calory values of foods and drinks, and an index are included. The book belongs to the *Arzt als Erzieher* series.

HOW SAFE IS HOME?

By Howard W. Green. Cleveland Health Council, Cleveland, O. 50 cents. $10\frac{3}{4}$ x $8\frac{3}{8}$; iii + 48; 1934 (paper).

This is a statistical study of accidents in Cleveland homes from January 1929 to July 1934. All types of accidents are classified according to age, sex, economic status, and geographic distribution in the city. Falls and burns were the two most frequent. There are numerous maps, graphs, and tables.

BULLETIN DER SCHWEIZERISCHEN GESELLSCHAFT FÜR ANTHROPOLOGIE UND ETHNOLOGIE 1934–35. *11. Jahrgang.*

Société Suisse d'Anthropologie et d'Ethnologie, Institut Anthropologique de l'Université, Zurich. 2 francs. 9 x $6\frac{1}{4}$; 35; 1934–35 (paper).

JUVENILE-COURT STATISTICS AND FEDERAL JUVENILE OFFENDERS, 1932. *Based on Information Supplied by 267 Juvenile Courts and by the United States Department of Justice. Sixth Annual Report. Bureau Publication No. 226.*

By U. S. Department of Labor, Children's Bureau. U. S. Government Printing Office, Washington. 10 cents. $9\frac{1}{4}$ x $5\frac{7}{8}$; iii + 129; 1935 (paper).

ZOÖLOGY

A STUDY OF THE LIFE HISTORY AND FOOD HABITS OF MULE DEER IN CALIFORNIA. *A Contribution from the Wildlife Division, United States National Park Service.*

By Joseph S. Dixon. Wildlife Division, United States National Park Service, 328

Hilgard Hall, Berkeley, Calif. 25 cents. 9 x 6; 146; 1934 (paper).

This is an important, complete, and interesting compilation of field observations on the life history and feeding habits of *Cervus hemionus* (= *C. macrotis*) which is found in northeastern California. In summarizing the breeding habits Dixon says:

> From "sign" and tracks left in the snow, it is evident that most of the mating takes place at night.
>
> During the rutting season I have followed mule deer about for days at a time in freshly-fallen snow, and have found that the normal mating practice is as follows: The most virile bucks are those that are just reaching maturity. Such bucks may, in some cases, be three-pointers, although the majority have acquired the fourth tine or point to each antler. My field studies of deer in Yosemite and in the Sequoia region, which have extended over a number of breeding seasons, have shown that in each season 90 per cent of the effective mating was accomplished by such dominant bucks. The usual procedure is as follows: As soon as their antlers become hardened and are freed of velvet, the bucks stage a series of combats which demonstrate which bucks are dominant and which are the weaker individuals. Through such elimination contests, a practical understanding is reached among all the bucks as to which is superior, and each buck learns his proper place. In most instances, the weaker bucks give way to their superiors whenever they appear on the scene.
>
> The oestrum period in female deer varies, so that all the does are not ready to mate at the same time. When the pre-oestrum period is reached by a doe, she is singled out and closely followed by one of the dominant bucks until she is ready to mate. This "running" of does by bucks may extend from two to five days and is often confused with actual mating, which takes place subsequently as the final chapter in the mating episode. Mating having been accomplished, the "herd" buck hunts up a new doe and runs at her side until she is ready to mate.

There are about eighty photographs, most of them very good, and all of them aptly chosen, and there are three tables showing the trees, shrubs, and herbs known to be used for food by this species. There is an index.

THE AMERICAN EAGLE. *A Study in Natural and Civil History.*

By Francis H. Herrick. D. Appleton-Century Co., New York. $3.50. $8\frac{5}{8}$ x $5\frac{3}{4}$; xx + 267 + 31 plates; 1934.

Professor Herrick was a pioneer in the precise and detailed scientific study of bird behavior. The present volume is a worthy capstone to his former achievements in this direction. The American bald eagle (*Haliæetus leucocephalus*) is obviously not an easy subject for intimate study, but in 1926 Professor Herrick built a 90-foot steel tower 38 feet away from and overlooking an eagle's nest at Vermilion, Ohio. From the pent-house on the top of this observation tower were made the records and photographs that form the substance of this book. It is a fascinatingly interesting and valuable contribution to zoölogy and comparative psychology that must form a part of every well-rounded biological library.

After the completion of the zoological discussion the last five chapters are devoted to the historical and political matters with reference to which the eagle has served as an emblem. While these chapters are interesting and scholarly, we cannot escape the feeling that it would have been better strategy to have published them as a separate book rather than as a somewhat unrelated appendage to a sound and fine contribution to zoölogy.

The photographic illustrations merit especial commendation, as does also the detailed and expertly constructed index.

WESTERN DUCK SICKNESS: *A Form of Botulism. U. S. Department of Agriculture Technical Bulletin No. 411.*

By E. R. Kalmbach, with Bacteriological Contributions by Millard F. Gunderson. U. S. Government Printing Office, Washington. 10 cents. $9\frac{1}{8}$ x $5\frac{3}{4}$; 82; 1934 (paper).

Clostridium botulinum, type C, was shown to be the cause of an extremely destructive disease affecting migratory water fowl in the Western States. The lines of evidence were:

> (1) the similarity of the clinical picture of the disease in the field with that produced experimentally by the administration of the toxin of pure cultures of type *C botulinum;* (2) the frequent recovery of the causative organism from the tissues of affected birds in distinction from its absence from the tissues of healthy birds; (3) the demonstration in the field of the toxin of type *C botulinum* in foods and water commonly ingested by birds; and (4) the fact that the incidence, course, and disappearance of duck sickness in the field conforms to the influence of environmental factors in a manner highly suggestive of botulism.
>
> An estimated loss of a quarter of a million birds at the north end of Great Salt Lake in the summer and fall of 1932 points to the current importance of the malady as a destroyer of wild life. Not only

ducks but a multitude of other birds succumb: at present the list of known victims comprises 69 species, in 21 families of wild birds.

Apparently, man is immune to the disease. There is an annotated list of the 69 species of birds affected and a bibliography.

LES POISSONS ET LE MONDE VIVANT DES EAUX. *Études Ichthyologiques et Philosophiques. Tome Septième. L'Abîme des Grands Fonds Marins.*

By Louis Roule. Librairie Delagrave, Paris. 42 francs (paper); 70 francs (leather). 10 x 6½; 326 + 16 plates; 1934.

LA VIE DES REPTILES DE LA FRANCE CENTRALE. *Cinquante Années d'Observations Biologiques.*

By Raymond Rollinat. Delagrave, Paris. 75 francs (paper); 110 francs (cloth). 10 x 6½; 342 + 35 plates; 1934.

The first of these two books is the seventh volume of a work on fishes and other water animals which will eventually comprise nine volumes. This present one is devoted to deep sea fish.

The second book here noted gives a résumé of the author's observations, covering a period of fifty years, on reptiles indigenous to Central France. The observations were made on specimens housed in his own garden. They include one species of turtle, five of lizards and seven of snakes.

Both books are written in an interesting manner, and are illustrated profusely with text figures, photographs and colored plates. Neither volume is provided with an index, but this lack is partly met by detailed tables of contents. They belong to a commendable series of natural history books put out by the publishers.

HVALRÅDETS SKRIFTER. *Scientific Results of Marine Biological Research. Nr. 9. Pelagic Whaling in the Antarctic. IV. The Season 1933–34.*

By Johan Hjort, J. Lie and Johan T. Ruud. With a note on: Limits of the Pack-Ice in the Antarctic in the Area Between 40° W and 110° E, by H. E. Hansen. Edited by Universitetets Biologiske Laboratorium. Jacob Dybwad, Oslo. 10¾ x 7; 59 + 7 plates; 1934 (paper).

Another number in this fine series dealing with the whaling industry. The present volume analyzes the catch and yield of whale oil for the 1933–34 season in Antarctic waters. The study is concerned with estimating whether the current practices in the whaling industry are adequate to secure the greatest economic return without depleting the whale population. The authors feel that this is being accomplished. The yield from fin whales and sulfur whales is converted into proportions of blue whales and the determination of these fractions must be an important step in the work. The data and calculations upon which the present converting factors are based are given in an earlier paper of the series.

The second paper in this volume shows the limits of the Antarctic ice pack for each year from 1929 to 1934 with the exception of 1931 when there were no Norwegian expeditions to the Antarctic ice.

THE NATURE OF A BIRD'S WORLD.

By Eliot Howard. University Press, Cambridge; Macmillan Co., New York. $2.50. 8½ x 6; vii + 102; 1935.

This is a provocative essay on the extent to which field observations can be used as evidence in the analysis of the psychological processes of that class of vertebrates which "seems to mingle the blindness of an insect with the intelligence of an ape." The author is a well-known ornithologist who is at the same time a philosopher. His main concern here is endeavoring to account for the continuity that runs through the various actions of birds. It must not be difficult to explain specific types of behavior as due to instincts or hormones, at any rate many people seem to find it easy, but Howard has taken a bolder course and has outlined a larger problem. What sort of unitary principle connects the discrete activities of choosing and defending a territory, breeding, nest-making, and brooding? Obviously, there must be some link, since the same individual passes through these engrossing

activities, and Howard has a partial answer.

ANGLING WAYS.

By E. Marshall-Hardy. Herbert Jenkins, London. 7s. 6d. net. 7¼ x 4¾; 305; 1934.

English Isaak Waltonians will undoubtedly cheer this book for it gives much valuable and entertaining information on the technique of British Isles fishing. The material covered runs from straight ichthyology to philosophy (which is not all fishy) with particular emphasis attached to the "how" of angling. The author originally published the material as articles in the London *Evening News*.

American anglers, while not clicking to such names as "roach," "bream," "grayling," and "barbel," will nevertheless find the book well worth reading—and it may help them catch more "bass," "pike," "trout" and "musky."

THE HUNGARIAN PARTRIDGE IN THE GREAT LAKES REGION. *Bulletin No. 5.*

By Ralph E. Yeatter. School of Forestry and Conservation, University of Michigan, Ann Arbor. 35 cents. 9 x 6; 92; 1934 (paper).

Introductions of the European partridge into this country for game purposes have in part proved successful, but in numerous cases have been complete failures. The life habits, food and feeding habits from field observations and stomach analyses, mortality factors, and population fluctuations were all carefully studied by the author in the hope of solving this mystery. He concludes that the species is better adapted to agricultural conditions than our native game kinds, but it would increase more rapidly if safer nesting places were provided since the greatest losses occur as a result of mowing and other agricultural activities during the nesting period.

WILD ANIMAL MAN. *Being the Story of the Life of Reuben Castang.*

By R. W. Thompson. William Morrow and Co., New York. $3.00. 8½ x 5½; 296 + 10 plates; 1934.

A story of the life of one of the great animal trainers of our times. An Englishman, with animal training a family tradition, Reuben went at the age of 13 to Hamburg where he was apprenticed to the Hagenbeck Company and worked with animals straight from the jungle. In 1900 he brought Hagenbeck's circus to America. Chimpanzees ultimately became his favorite animals and he has appeared before many people and in the films with some of the twenty-nine chimpanzees which he himself has captured alive in the jungle and trained. Mr. Thompson has produced a highly entertaining book. It has a few illustrations but is not indexed.

NATURAL HISTORY OF VERTEBRATES (*Except Birds*). *A Laboratory and Field Guide. Revised.*

By Frank N. Blanchard. Edwards Bros., Ann Arbor, Mich. $3.00. 11 x 8½; ii + 82 + extra copies of forms; 1935.

The biologist who is interested in really scientific natural history has now a fine manual to guide his studies. This volume contains keys for classifying the vertebrates, notes on habitat and environmental conditions and excellent bibliographies. In addition to the strictly field studies there are very good directions for the laboratory study of material collected. This is a fine piece of work from all points of view.

LA CHASSE DES ANIMAUX A FOURRURE AU CANADA.

By Benoit Brouillette. Gallimard, Paris. 30 francs. 9 x 5½; xvi + 202 + 24 plates; 1934 (paper).

Hunting and trapping of fur-bearing animals is still an important Canadian industry. The author reviews its historical origin and describes the physical and climatological aspects of the country in relation to the animals, the routes of the professional hunters and trappers, their mode of life and the economic value of their products. The author's vivid style adds much to the feeling of adventure that

this subject inevitably arouses in the reader. There is a lengthy bibliography.

NEW ZEALAND BEETLES AND THEIR LARVAE. *An Elementary Introduction to the Study of Our Native Coleoptera.*

By G. V. Hudson. G. V. Hudson, Hillview, Karori W. 3, Wellington, New Zealand. 25 shillings. 8½ x 5¼; 236 + 17 plates; 1934.

As implied by the title this volume is *sensu stricto* an annotated, taxonomic list of the Coleoptera of New Zealand. The material is organized by families with all genera and species completely indexed at the end of the book. While not of great interest to the American specialist the volume will undoubtedly reach the handbook stage for New Zealand entomologists.

INFANTS OF THE ZOO.

By E. G. Boulenger. E. P. Dutton and Co., New York. $2.50. 8¼ x 6½; xiv + 145; 1934.

This is an excellent volume for school libraries. The author writes interestingly on many things pertaining to the difficulties of rearing young animals. His subjects are mammals, birds, reptiles, amphibians and fishes, chiefly those that were born in two English zoological gardens. A valuable addition to the volume are the fifty photographs showing the babyhood of many of these animals.

TERMITES AND TERMITE CONTROL. *Second Edition, Revised.*

By Charles A. Kofoid, Editor-in-Chief; S. F. Light, A. C. Horner, Merle Randall, W. B. Herms, Earl E. Bowe, Termite Investigations Committee Editorial Board. University of California Press, Berkeley. $5.00. 9¼ x 6⅛; xxvii + 795; 1934.

A review of the first edition of this report has already appeared in this REVIEW. The present edition has been thoroughly revised and additional material added, also an index (which was omitted in the first edition). The book is intended primarily for biologists, architects, engineers, contractors, building inspectors, and users of wood, but the householder will also find it highly useful in helping him to decide whether he is being imposed upon by the too energetic salesman of insecticides.

THE SPINY DOGFISH. *A Laboratory Guide.*

By Alvin R. Cahn. The Macmillan Co., New York. $1.10. 7½ x 5; xii + 94; 1934.

This seems to be not a new edition but a reprinting of the 1926 edition which was reviewed in these columns, Volume 2, page 572. Since no change can be discovered between the two volumes there seems to be nothing to add to the earlier review.

THE EXTERNAL ANATOMY OF THE PARLATORIA DATE SCALE, PARLATORIA BLANCHARDI TARGIONI TOZZETTI, WITH STUDIES OF THE HEAD SKELETON AND ASSOCIATED PARTS. *U. S. Department of Agriculture Technical Bulletin No. 421.*

By F. S. Stickney. U. S. Government Printing Office, Washington. 10 cents. 9⅛ x 5⅞; 67 + 1 plate; 1934 (paper).

A thorough study of the external anatomy and endoskeleton of the head and associated parts for all instars of both sexes of the *Parlatoria* date scale. This is the most dangerous insect attacking palms in the date growing region of the United States.

TIERE *wie sie wirklich sind. Ein Bilder- und Lesebuch für Jedermann.*

By L. Heck. Paul Parey, Berlin. 4.80 marks. 9½ x 6¾; 120; 1934.

The main attraction of this book is a series of excellent photographs of mammals and birds taken in the Berlin Zoo. It is interspersed with short, descriptive texts about the animals depicted, stressing the unique features of each. The author was for many years director of the Zoo.

FIELD BOOK OF INSECTS *of the United States and Canada, Aiming to Answer Common*

Questions. Third Edition, Rewritten to Include Much Additional Material.

By Frank E. Lutz. G. P. Putnam's Sons, New York. $3.50. 6¾ x 4; vi + 510; 1935.

An old, esteemed friend brought up to date. This is a book to be included, along with Gray's *Botany*, in the equipment of the natural history student.

BOTANY

THE STRUCTURE AND REPRODUCTION OF THE ALGAE. *Volume I. Introduction, Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglenineae, Colourless Flagellata.*

By F. E. Fritsch. University Press, Cambridge; Macmillan Co., New York. $8.00. 8½ x 5½; xvii + 791; 1935.

Until now there has been no adequate account of the morphology of the algae published in English, and Professor Fritsch's scholarly monograph will be welcomed by everyone working on the Protista.

> The two volumes in which I propose to accomplish this task are planned to deal essentially with morphological features, and points relating to the physiology and ecology of the Algae have been included only where their consideration appeared relevant to an understanding of the main subject-matter. Nor is this in any sense a taxonomic work. The outlines of classification given under the individual groups are intended merely to afford a synopsis for the reader, and taxonomic problems have only been discussed where they are of general morphological interest. Some attempt has been made, without entering into detail, to deal with the numerous cytological papers that have been published during the present century, but this has certainly been the hardest part of my task.

This volume treats eight of the eleven classes of algae Fritsch recognizes, namely the Chlorophyceae (Isokontae), Xanthophyceae (Heterokontae), Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, and the Euglenineae. "Unless purely artificial limits are drawn, the designation alga must include all holophytic organisms (as well as their numerous colourless derivatives) that fail to reach the higher level of differentiation characteristic of the archegoniate plants." Accordingly, the Flagellata are treated in this volume, also.

Many things have been done to make this a reference book of uncommon usefulness to students of the Protista. There are nearly 250 illustrations, most of them occupying a full page, taken from the literature. Extensive bibliographies covering the period 1890 to 1933 appear at the end of the discussion of each taxonomic group and each citation is indexed in the author index. There is an excellent subject index.

THE FLORA OF THE NIAGARA FRONTIER REGION. *Ferns and Flowering Plants of Buffalo, N. Y., and Vicinity.*

By Charles A. Zenkert. Buffalo Society of Natural Sciences, Buffalo. $2.00. 9¾ x 8½; x + 328 + folding map; 1934.

The area included in this floristic and ecological survey lies within a radius of about 50 miles of Buffalo, New York, in a very interesting physiographic region which is well described. To the north and to the west are Lakes Ontario and Erie and these so ameliorate the climate that the Austral, or temperate zone, flora lies on the north and the Boreal, or sub-arctic, flora lies on the margin of the Allegheny Plateau to the south. Most of the region was glaciated and special attention is given to the flora of a district which was not glaciated.

Besides a description of the geological and meteorological features of the region the introductory section of 67 pages gives a brief account of the botanical reports of early explorers and of the economic history of the region insofar as it bears upon deforestation and the use of the land for agriculture. The greater part of the book, about 200 pages in length, is given over to a listing by families of the 563 genera and the 1,702 species of vascular plants found in this region. For each species there is brief mention of its frequency of occurrence throughout the region and of its relative abundance in the places where it does grow. The type of soil on which it is found is also noted and there is a short list of local stations for each species. The ecology of the region is discussed in

detail in the last section of the book and plant lists and general descriptions are given for each of the major plant communities.

Not counting the scattered explorations of early taxonomists beginning with Peter Kalm in 1750, serious botanical work on the flora of this region has been in progress since 1862 and the publication of this book is an achievement for which the Buffalo Society of Natural Sciences and the author deserve to be congratulated. Everything possible has been done to make this a useful reference book; there are numerous excellent maps showing both geology and topography, the photographs of flowering plants and of ecological communities are numerous and are unusually good, the bibliographic references to other floras and to other sources are adequate, and there is an index to genera, families, and common names.

POT CULTURE TESTS OF FOREST SOIL FERTILITY. *With Observations on the Effect of Varied Solar Radiation and Nutrient Supply on the Growth and Nitrogen Content of Scots and White Pine Seedlings. The Black Rock Forest Bulletin No. 5.*

By Harold L. Mitchell. The Black Rock Forest, Cornwall-on-Hudson, N. Y. $2.00. 9 x 6; xi + 138 + 2 folding charts; 1934 (paper).

The primary object of this experiment was to make a biological test of the various soils found within a forest in the Hudson Highlands of New York State. The first step was to calibrate, as it were, tree seedlings so that from their response to a soil sample the availability of the several mineral nutrients could be deduced. This prompted a very careful physiological experiment on the growth of Scots pine and white pine seedlings under different intensities of light and with different supplies of mineral salts. The quantitative data thus obtained were capably analyzed. Among other things, it was found that the density of the blue-green color of white pine seedlings was directly proportional to the amount of nitrogen supplied, and that a deficiency of phosphorus caused a purple needle color. The second step was to grow seedlings in samples of the soil to be tested, and to test the soil for mineral deficiency in two ways. If, for example, a possible deficiency of nitrogen were suspected, salts containing the elements P, K, Ca, Fe, Mg, and S were added to the soil sample and growth was compared with growth in a control soil sample which received all these elements and nitrogen in addition. Seedling color provided an additional test. In samples of soil from the four major soil types of the forest Ca and K were abundant, and only an exposed ridge soil lacked N. All soils were deficient in P. This publication deserves the attention of everyone interested in the mineral nutrition of plants. The experimentation was admirably executed and the results are well presented in full detail. There is a bibliography covering six pages.

DIE STOFFAUSSCHEIDUNG DER HÖHEREN PFLANZEN. *Monographen aus dem Gesamtgebiet der Physiologie der Pflanzen und der Tiere. Band 32.*

By A. Frey-Wyssling. Julius Springer, Berlin. 28 marks (paper); 29.40 marks (cloth). $8\frac{1}{2}$ x $5\frac{3}{4}$; xii + 378; 1935.

Frey-Wyssling's initial definition indicates the scope of his monograph:

> *Ausscheidungsstoffe* can be defined as materials which are secreted by the living protoplasm and which are not used again in metabolism. In contrast to these are reserve substances which are also lifeless deposits but only temporarily eliminated from metabolism. According to this concept structural substances such as mineral deposits and organic inclusions like resin and rubber which finally are eliminated from metabolism belong to the Ausscheidungsstoffe while the reserve substances like starch, aleuron, fat, and certain hemicelluloses can be remobilized.

The first hundred pages deal with the submicroscopical structure of the cell wall, and the discussion of the data obtained by the use of X-rays, polarized light, and other optical methods is enough to make this a valuable book. The physiological aspects of the formation of cell walls are discussed in the next fifty pages. The next 120 pages deal with the physical chemistry, physiology, and cytology of the deposition of minerals in plants. The last hundred pages concern excretion and

secretion. It makes a valuable reference book for plant physiologists and its usefulness is increased by an extensive bibliography and a good index.

KEY TO THE RUSTS OF THE PACIFIC NORTHWEST. *University of Washington Publications in Biology, Volume 3.*

By J. W. Hotson. University of Washington Press, Seattle. $1.50. 10 x 7; 193; 1934 (paper).

Hotson has done a very useful piece of work in a creditable manner.

Many rusts are so highly specialized that they confine their activities to relatively few species of the host, some to a single species, others to different species in the same genus; rarely do they produce the same spore-forms on more than one host family. Utilizing this characteristic of rusts an attempt has been made to identify them by means of the host. The general plan of the paper has been to list all the rusts reported for the four states, Washington, Oregon, Idaho, and Montana under the family and genus on which they occur. These families and the genera within the families are arranged alphabetically. Under each host-genus an attempt has been made to separate the various rusts by means of a Key.

There ought to be similar surveys for all sections of the country but in their absence this book will probably prove to be a valuable aid to mycologists interested in the Uredinales found in the northern half of the United States. There are two indexes, one for host names and one for rust names.

DER ABBAU. *Eine entwicklungsgeschichtliche Studie zum Senilitäts- und Fortpflanzungsproblem.*

By Franz Ragaller. Gustav Fischer, Jena. 5.60 marks. $9\frac{3}{4}$ x $6\frac{5}{8}$; 85; 1934 (paper).

This is a general and theoretical discussion of the results of a ten-year investigation of the problem of degeneration in a particular variety of potatoes—a problem that horticulturists, plant breeders, and botanists generally have struggled with for years. Potato varieties "run out," as the common phrase goes. But why they degenerate has never been clearly explained. Other vegetatively propagated forms do not, as witness, for example, the Baldwin apple.

Dr. Ragaller has not finally solved the problem. But he has put it in better order and more sharply analyzed the *Fragestellung* than anyone before him. His discussion is of great interest and importance to the general biologist. He argues with cogency and force, and in fact seems to us to prove, that the problem of degeneration is one that never will be solved by the "crucial experiment" type of research, however carefully and ingeniously planned and executed. The reason is that degeneration is a combined ecological, senility, and disease problem *all in one*, the several aspects being indissolubly united in space, time and essence.

PRACTICAL PLANT ANATOMY. *An Elementary Course for Students.*

By Comyns J. A. Berkeley. University of London Press, London. 3 shillings. $7\frac{1}{4}$ x $4\frac{3}{4}$; 112; 1934.

There is no better book than this for people taking up microscopy as a hobby or for teachers of general botany or plant histology who need a little guidance in planning their laboratory work. The use of the microscope and the various operations involved in cutting, staining, studying, and preserving free-hand sections of plant tissues are explained in minute detail, and this manual can be recommended as a trustworthy guide in these matters. There are about a hundred laboratory exercises arranged in order of difficulty and these include most of the kinds of material usually assigned to students in courses of this kind. These laboratory instructions are quite complete. There is a table of the simple microchemical tests and directions for preparing the reagents are given.

Teachers should find the check list of plant materials, their sources and manner of preservation, particularly useful. The use of the microtome is not discussed. There is an index.

THE MYSTIC MANDRAKE.

By C. J. S. Thompson. Rider and Co., London. 15 shillings net. $8\frac{1}{2}$ x $5\frac{1}{2}$; 253 + 8 plates; 1934.

No plant has been the subject of such

curious lore or has been so extensively used in mystic rites as has the mandrake. Because of the resemblance of the root to the human form it was believed to possess occult properties which could cause it to become animated. Many treatises have been written on its virtues as an anaesthetic, as a love charm, as a cure for sterility, its power to invigorate the aged as well as its demoniacal and evil powers. The author, honorary curator of the historical collection of the Museum of the Royal College of Surgeons of England, has given an interesting and authentic history of this plant. The volume is illustrated and indexed.

DICTIONARY *of Terms Relating to Agriculture, Horticulture, Forestry, Cattle Breeding, Dairy Industry and Apiculture. In English, French, German and Dutch.*

Compiled by T. J. Bezemer. The Williams and Wilkins Co., Baltimore. $8.00. 8 x 5½; vii + 1061; 1934.

This polylingual dictionary of words and phrases used in the literature of agriculture, horticulture, forestry, and animal husbandry, has a great deal of usefulness in supplementing the standard dictionaries hitherto available. For each one of the four languages, English, German, Dutch and French, there is a separate dictionary giving the equivalents of technical terms in the three other languages without further definition. The names of plants and animals are also rendered by their Latin equivalents. It is a very satisfactory piece of work, on the whole. It overlaps literary dictionaries very little, gives satisfactory idiomatic equivalents in most cases, and is reasonably complete.

MORPHOLOGY

ELEMENTARY HUMAN ANATOMY. *Based on Laboratory Studies.*

By Katharine Sibley. A. S. Barnes and Co., New York. $4.50. 9¼ x 6⅛; xx + 360; 1935.

This undergraduate textbook of human anatomy is written as a foundation course for the study of kinesiology and physiology and for the students and teachers of physical education. The writer has placed special emphasis on osteology, syndesmology, myology and the nervous system to aid the teacher of corrective gymnastics and the physiotherapist in muscle examination and muscle reëducation.

The plates, many of them colored, have been taken from the standard atlases of human anatomy and appear to have been judiciously selected. The text explains the methods of demonstrating on living subjects the various structures of the human body and their mode of action. Detailed, technical, anatomical descriptions are not given. There are more than 200 plates, excellently reproduced, and there is an excellent index.

AIDS TO EMBRYOLOGY. *Second Edition.*

By Richard H. Hunter. William Wood and Co., Baltimore. $1.25. 6¼ x 4; viii + 172; 1934.

The purpose of this small book, according to its author, is to give the medical student enough of a survey of human development so that he will be able to interpret common abnormalities experienced in the dissecting-room and obstetrical wards. The book is divided into twelve short chapters dealing with the development of specific organs and systems. The work will probably be useful to students and physicians who wish to review some of the essentials of mammalian embryology with a minimum expense of time. It is clearly written in summary style.

OUR VANISHING HAIR. *A Dissertation on Human Hair Production with Special Reference to Premature Baldness.*

By Charles Nessler. Alwyn-Schmidt Publishing Co., New York. $2.00. 8 x 5⅜; 140 + 8 plates; 1934.

The author again expounds some quaint theories about hair. Premature baldness is said to result solely from the custom of periodic hair trimming. Since cutting the hair removes its weight, the hair follicle becomes weak and gradually loses its gripping power until in adulthood it can no longer hold on to even the finest

and lightest hairs. Another new and somewhat startling idea is that hair migrates. Since the hair urge is denied by repeated trimmings a full expression on the head it migrates in man to the chest and limbs. The author limits the hairy regions arising as secondary sexual characteristics to armpits, pubic region and lower face. Growth of hair on chest and limbs is correlated in his belief with loss of hair on the head. He has nothing to say about inheritance of baldness.

GRUNDRISS DER CYTOLOGIE.
By Lothar Geitler. Gebrüder Borntraeger, Berlin. 19.20 marks (paper); 21 marks (bound). 10 x 6½; viii + 296; 1934.

The examples of cytological phenomena illustrated and discussed in Geitler's introductory textbook of cytology are drawn from all parts of the plant and animal kingdoms and Geitler's own field, the Protista, is also well represented. Fittingly enough, the book is dedicated to Karl Belar, for Geitler has been very much influenced by his former associate and has used many of his illustrations. The illustrations, more than 200 in all, have been taken from the literature and from unpublished work and are both well chosen and well reproduced. Fullest advantage has been taken of the comparative method in the description and analysis of cytological phenomena. There are few bibliographic citations but there is a good index.

A HISTORY OF EMBRYOLOGY.
By Joseph Needham. The Macmillan Co., New York. $4.00. 9⅛ x 6¼; xviii + 274 + 16 plates; 1934.

This is essentially an elaboration of the early part of the two volume work on *Chemical Embryology* by the same author which was published in 1931. There is a good deal of new material added but the general order and the topics considered are the same here as in the earlier publication. This book represents a very interesting and scholarly addition to the field of the history of biology.

PHYSIOLOGY AND PATHOLOGY

THE VITAMIN B. REQUIREMENT OF MAN.
By George R. Cowgill. Published for The Institute of Human Relations by Yale University Press, New Haven. $4.00. 9 x 6; xix + 261 + 4 plates; 1934.

Professor Cowgill is trying to put together the results of animal experimentation on vitamin B_1 requirements in such a way that the knowledge thus gained may be more directly applied to the study of human dietaries. The absolute amount of any vitamin required by any animal might be expected to bear some relation to the animal's body weight. For some time, the relation was supposed to be a constant and direct one and grams of vitamin per gram of body weight of pigeon and rat were used interchangeably. But it has been found that this is not altogether true, at least for vitamin B_1. Pigeons seem to require more vitamin B_1 per unit of body weight than do dogs.

Since it is impossible to subject humans to the rigorous experimentation necessary to determine such a relationship, Cowgill proposes to extend knowledge gained from animal experimentation. This necessitates determining the relation between body weight and vitamin requirement in a way that will hold from one species of animal to another. Cowgill's own thesis is that the vitamin B_1 required is a function of metabolism. His first approach is that the vitamin B_1 required is directly proportional to body surface (determined as body weight $^{\frac{2}{3}}$) but this doesn't seem to work very well in giving comparable results. So then he tries different powers of body weight and finally reaches the conclusion that vitamin B_1 is directly proportional to the 5/3 power of body weight. This seems to be a very important fact and one that should be very carefully and accurately determined. We should like to see this relation determined by other and more efficient statistical techniques.

A subject index would increase the usefulness of the book.

THE PATIENT AND THE WEATHER. *Volume II, Autonomic Dysintegration. Volume III, Mental and Nervous Diseases.*

By William F. Petersen and Margaret E. Milliken. Edwards Bros., Ann Arbor, Mich. Vol. II, $5.00; Vol. III, $6.50. $10\frac{3}{4}$ x $8\frac{1}{4}$; Vol. II, xx + 530; Vol. III, xvi + 375; 1934.

The author revives the Hippocratic concept of the influence of weather conditions on disease manifestations by emphasizing the effect of meteorologic changes on the autonomic nervous system. In brief his point of view is that vasomotor instability has not only an important rôle in the progress of certain diseases or in determining predisposition to them, but also in the degree of susceptibility to clinical manifestations of infections. The instability, meaning abnormal fluctuations in vasoconstriction and vasodilation is, in the author's opinion, directly related to barometric pressure, temperature, humidity, etc., and shown by changes in blood pressure, blood pH, K/Ca, CO_2 and cholesterol contents. It is also associated with the individual somatic habitus.

In Volume II the author discusses the effect of meteorologic alterations on the unstable individual relative to headaches, epilepsy, eclampsia, mucous colitis, gastric ulcers, certain allergic conditions, arthritis, Ménière's disease, etc.

In the first part of Volume III he amplifies his previous conclusions and describes the different meteorologic conditions in the United States in relation to the geographic distribution of congenital physical malformations; the seasonal distribution of the conception of mentally superior and inferior individuals, of manic depressives and schizophrenics; the seasonal incidence of suicide. One of his tentative conclusions is that conceptions during the meteorologically stable months produce more often normal or dull-witted individuals while those occurring during the unstable months more frequently produce insane or mentally superior men. The second part of this volume is dedicated to different forms of psychosis, multiple sclerosis, tabes and paresis, poliomyelitis and meningitis.

The author is guarded in his conclusions and justly so since sufficient evidence is not given. For each disease condition he presents a few selected cases with detailed medical history, and physical and biochemical examinations, meteorologic charts and in some instances anthropometric data. It is a very interesting study and important from the standpoint of human constitution but it will necessitate further investigation both experimentally and statistically.

De Venarum Ostiolis, 1603, of Hieronymus Fabricius of Aquapendente (1533?–1619). *Facsimile Edition.*

With Introduction, Translation and Notes by K. J. Franklin. Charles C. Thomas, Springfield, Ill. $3.00. $9\frac{1}{2}$ x 6; 98 + 3 plates; 1933.

When Boyle asked Harvey what had led him to think of a circulation of the blood, the latter answered

> that when he took notice that the Valves in the Veins of so many several Parts of the Body, were so Plac'd that they gave free passage to the Blood Towards the Heart, but oppos'd the passage of the Venal Blood the Contrary way: He was invited to imagine, that so Provident a Cause as Nature had not so Plac'd so many Valves without Design: and no Design seem'd more probable, than That, since the Blood could not well, because of the interposing Valves, be Sent by the Veins to the Limbs; it should be Sent through the Arteries, and Return through the Veins, whose Valves did not oppose its course that way.

Now from 1600 to 1602 Harvey had studied at Padua under the celebrated anatomist Fabricius of Aquapendente, who was the first to describe the valves of veins in detail. Thus although Fabricius was prevented by his adherence to the ideas of Galen from drawing those inferences which his pupil later made, his discovery was an important step in the process. Dr. Franklin gives a reduced facsimile and a translation of Fabricius' description of the veins, as well as a graphic brief account of his life, a summary of previous work on the vein valves, and a history of the theater of the school of anatomy at Padua with architectural drawings of the theater, still existing, which Fabricius himself caused to be built.

A New Deal in Liquor. *A Plea for Dilution.*

By Yandell Henderson. Also a Reprint-

ing of *An Inquiry into the Effects of Ardent Spirits upon the Human Body and Mind, by Dr. Benjamin Rush. Doubleday, Doran and Co., Garden City, N. Y.* $2.00. 8 x 5½; x + 239; 1934.

Professor Henderson starts with the thoroughly sound assumption that Americans are going to continue to drink alcoholic beverages. For him, the liquor problem resolves itself into the problem of weaning people away from whisky and other concentrated alcoholic beverages and of substituting beer and other wholesome and harmless alcoholic beverages. There are two obstacles to this program, the stupidly perverse taxation policy which makes whisky cheap and beer expensive in terms of their alcohol content, and the practice of selling beer and whisky over the same bar. Professor Henderson's position throughout the book is that of a toxicologist analysing a problem in which public health is involved. He addresses himself to people concerned with the legal control of the sale of alcoholic beverages, presents briefly but adequately and fairly the scientific and historical data that bear most directly upon the problem, and concludes with a program he believes will be conducive to temperance. In an appendix of about 30 pages he reprints a pamphlet first published in 1784 by Dr. Benjamin Rush who set himself the same problem as Henderson. There is an excellent index.

THE COMPARATIVE PHYSIOLOGY OF THE CONDITIONED MOTOR REFLEX. *Based on Experiments with the Pig, Dog, Sheep, Goat, and Rabbit. Comparative Psychology Monographs, Vol. 11, No. 1, Serial No. 51.*

By H. S. Liddell, W. T. James, and O. D. Anderson. Johns Hopkins Press, Baltimore. $1.50. 10 x 6⅞; 89; 1934 (paper).

The human nervous system is susceptible of disorders which are directly caused by social maladjustment. The normal adult assumes social responsibilities and conforms to an intricate schedule of habits. When he is able to discharge his obligations successfully and hence to maintain a stable system of behavior, mental life pursues a healthy course. But social life may become too intricate. An individual may *imperceptibly* impose upon himself too many duties. His life becomes too regimented and self-imposed restraints bulk dangerously. Such an individual has cut off his avenues of escape and can no longer secure adequate relief from dangerous nervous tension through evasion or procrastination. When serious predicaments arise a mental derangement may result because the individual has already been effecting intricate adjustments which have taxed his nervous capacity to the limit. The added demand calls for that which cannot be supplied, and nervous bankruptcy follows.

This monograph shows how such neurotic conditions may be produced in experimental animals. There is also a considerable amount of detail about the experimental procedure in conditioned reflex experiments.

REVUE D'IMMUNOLOGIE. *Tome 1, No. 1, Janvier 1935.*

Edited by Robert Debré, G. Ramon, Pasteur Vallery-Radot. Masson et Cie, Paris. Subscription: (6 numbers per year): France, 80 francs; foreign, 90 francs; single number 15 francs. 9½ x 6½; 112; 1935 (paper).

To bring before biologists and clinicians the more important work being done in the field of immunology and the practical application of many of the discoveries being made is the aim of this new journal. In its pages will be published original memoirs, articles bearing on actual problems of immunity, and critical reviews. The first number contains the following papers (in French): Immunity and immunization against typhus; position and actual state of the question, by Jules Bordet; Vaccination against diphtheria and tetanus by means of specific antitoxins and associated vaccines, now in practise, by G. Ramon; Comparison of provoked and spontaneous anaphylaxis, by Pasteur Vallery-Radot and G. Mauric; Mode of action of immunity created by diphtheria antitoxin; experimental study, by G. Ramon, Robert Debré and G. Sée; The problem of allergic migraines, by Jean Hamburger.

ALCOHOL AND ANAESTHESIA.

By W. Burridge. Williams and Norgate, London. 2s. 6d. net. 8½ x 5½; 65; 1934 (paper).

On the basis of his experiments the author

comes to the conclusion that alcohol exerts independent actions of both exaltation and depression on the same tissue at the same moment. Under the older theories of the physiology of alcoholic action Burridge claims it has been impossible to explain this fact which his collected data and interpretations fit quite nicely. In brief, the new theories developed in the book are "that central neurones are rhythmically active structures which possess two sources of potential for their energy manifestations and that the physiological basis of an idea is a group of nerve cells rhythmically active in unison."

The reader will have to keep awake if he is to find out what this book is about and why—however, he may take some comfort in one of the author's conclusions that the "intelligent and clean-minded" may be able to imbibe alcoholic liquors with benefit.

THE PHYSIOLOGY OF HUMAN PERSPIRATION. *By Yas Kuno. J. and A. Churchill, London.* 12s. 6d. 8 x 5¼; x + 268 + 6 plates; 1934.

The author, who is professor of physiology in the Manchuria Medical College, has devoted nine years to a study of the physiology of perspiration. The book contains a thorough survey of all important research in the subject up to the present, and a summary of the work done in his own laboratory. He points out that sweating is not as simple a physiological process as has heretofore been assumed. Sweating produced from emotional and sensory stimulation is controlled by a different cerebral center than that occurring as a result of high temperature. Sweating also has an important rôle as a physiological process, he believes.

The book is a thoroughly scholarly piece of work. There are 26 pages of bibliography devoted to papers published in the department and upon which the monograph is based.

STANDARD CLASSIFIED NOMENCLATURE OF DISEASE. *Second Edition. Compiled by The National Conference on Nomenclature of Disease; Edited by H. B. Logie. Commonwealth Fund, New York.* $3.50. 7⅜ x 4¾; xxi + 870; 1935.

The first (1933) edition of this *Standard Classified Nomenclature of Disease* was reviewed in Vol. 8, p. 375.

> The same general plan of classification of coding is followed in the new edition as in the old. . . . The most important changes will be found in the sections on endocrinology, neurology, diseases of the cardiovascular system, and diseases of the musculo-skeletal system; the latter two have been rewritten, not only to make them more complete and exact but to make reference easier. Errors and omissions have been corrected, and the Index has been enlarged by about two thousand items so as to facilitate cross reference between terms in common use and the terminology employed in the Classified Nomenclature. It now contains nearly 15,000 items.

RAPPORT SUR LE PÈLERINAGE AU HEDJAZ *de l'Année de l'Hégire 1352 (A.D. 1934). Conseil Sanitaire Maritime et Quarantenaire d'Égypte, Alexandria.* Free. 12½ x 9; 81 + 5 folding tables; 1934 (paper).

The annual pilgrimage to the Hedjaz has sent many hundreds of devout Mohammedans to the Moslem heaven what with cholera, typhoid, etc. In recent years the morbidity and mortality have greatly diminished. This statistical report issued by the Sanitary Council of Egypt explains this decrease and demonstrates again the benefits derived from strict sanitary measures. It deals with almost 10,000 pilgrims (circa 1/6 of the total) who came to the Hedjaz from Egypt or from other countries but passed through Egyptian parts and the Suez Canal. The pilgrims were given injections against typhoid, cholera and pest. Quarantine was established before the pilgrims were allowed to return and there they were given physical and laboratory examinations. The excellent results are immediately apparent from the many tables which summarize the data obtained from the reports of the health officers.

DAS GESUNDHEITSWESEN BEI ARISTOTELES. *By Paul Kalthoff. Ferd. Dümmler, Berlin and Bonn.* 12.80 marks (paper); 14.80 marks (cloth). 9⅛ x 6¼; xvi + 372; 1934.

Kalthoff expresses as one of his aims in writing this book the hope of "awakening in the medical man, historical, and in the philologist, medical, understanding." This is a compilation of what is written in the various works indisputably attributed to Aristotle, concerning various phases of hygiene and medicine. The chapter headings include social hygiene, exercise, clothing, climate, communicable and other diseases, anatomy, sexuality, psychiatry, medicinal plants, etc., etc. Numbers in the text refer to references given at the back of the volume which are complete even to page and column but at times the edition of the work used by the author is not made clear.

A short list of comparatively recent works on medicine and hygiene in ancient Greece and Rome is given in the introduction. The book has no index.

PHYSIOLOGIE ET PHYSIOPATHOLOGIE DU SYSTÈME RÉTICULO-ENDOTHÉLIAL.

By Albert H. Du Bois. Masson et Cie, Paris. 36 francs. 9½ x 6½; 204; 1934 (paper).

A critical review of the discoveries made between 1924 and 1933 relative to the reticulo-endothelial system. The first part which includes an excellent chapter on the morphology of the reticulo-endothelial system records the general experimental results regarding functional tests and vital fixation. The second part deals with the function of this system in normal and pathologic physiology; metabolism of pigments, lipoids, carbohydrates, water, proteins; the reaction to infectious diseases, phagocytosis and immunity. There follow chapters on the changes produced by different forms of therapy in disease. A comprehensive bibliography of 30 pages closes this fine work.

THE NUTRITIONAL ORIGIN OF CANCER.

By Edwin E. Ziegler. Edwin E. Ziegler, Box 2193, Boise, Idaho. $2.50. 9 x 6; iv + 92; 1934 (paper).

The author believes that there is enough statistical evidence to show conclusively that the incidence of cancer is directly proportional to the consumption of alkaline food. In European countries where a large quantity of alkaline foods are consumed there exist the highest death rates from cancer, and conversely primitive people, subsisting on a high protein and acid forming diet, have very little cancer. As cancer is thus a disease of civilization the best preventive measures would be to return to a primitive diet, high in acid forming foods and similar to that of our savage and nomadic ancestors.

HEALTH DENTISTRY FOR THE COMMUNITY. *A Study of the Present Needs and General Trends in the Provision of Community-wide Dental Care.*

By The Committee on Community Dental Service of the New York Tuberculosis and Health Association. University of Chicago Press, Chicago. $1.00. 8⅛ x 5½; xiii + 85; 1935.

A survey of the existing conditions of dental health in large urban communities shows that there is a deplorable lack of proper dental treatment, particularly among school children. A summary of the dental findings among 1,000 patients of the white collar class also indicates that present dental care for adults is far below what it should be to maintain a healthy community. The survey points out the need for socialization of dentistry, and offers, in the concluding chapters, a good working program.

OLD AGE—*Medically Considered.*

A Series of Papers by Medical Authorities on the Physical and Dietetic Treatment of Diseases and Disabilities of Old Age. Actinic Press, London. 3 shillings net. 8⅜ x 5½; 96 + 2 plates; 1934 (paper).

These papers, originally published in the *British Journal of Physical Medicine*, deal with the diet, ocular diseases, dental disease, early prostatic obstruction, neuritis, sciatica and lumbago, cardio-vascular disease, deafness, kidney disease, skin affections, respiratory disorders, the importance of exercises and recreations, and physical treatment of cardio-vascular sclerosis.

POUR VIVRE CENT ANS *ou l'Art de Prolonger ses Jours. Troisième Édition.*

By A. Guéniot. J.-B. Baillière et Fils, Paris. 14 francs. $7\frac{3}{8}$ x $4\frac{3}{4}$; 230; 1933 (paper).

When this third edition was published the author, a physician, was 101 years old. He regards the century mark as the "normal" life span and gives his reasons which are not very convincing. His advice on the means of attaining this age is the usual formula: temperance. It is to be presumed that the author himself followed a temperate regimen but there is no specific statement to this effect.

KONSTITUTION UND TUBERKULOSE IM KINDESALTER.

By Kurt Klare. Georg Thieme, Leipzig. 4 marks. 10 x $6\frac{5}{8}$; 42; 1935 (paper).

The writer discusses briefly the constitutional types and bodily habitus of children in relation to their susceptibility to tuberculosis. He includes a series of selected cases with family history, patient's past history and the habitus but is unable to arrive at any definite conclusions regarding the relative influence of these factors.

LA PROTIDÉMIE ET LA PRESSION OSMOTIQUE DES PROTIDES. *Recherches Expérimentales et Applications Cliniques.*

By Antoine Codounis. Masson et Cie, Paris. 36 francs. $9\frac{1}{2}$ x $6\frac{1}{2}$; 212; 1934 (paper).

Methods of technique and detailed observations are given on experimental work with animals and clinical with man concerning the protein equilibrium of the blood and osmotic pressure in normal and diseased conditions. The bibliography covers 11 pages.

BIOCHEMISTRY

ÉLÉMENTS DE CHIMIE VÉGÉTALE.

By N. Wattiez and F. Sternon. Masson et Cie, Paris. 100 francs. $9\frac{3}{4}$ x $6\frac{3}{8}$; 729; 1935 (paper).

This is one of the best reference books on plant biochemistry to appear in recent years. It has been written primarily to facilitate the qualitative and quantitative analysis of plant products, and several kinds of information and numerical data are concisely presented. Much use has been made of tabular data and the authors have shown no little skill in reducing physical, chemical, and pharmaceutical data to tabular form or to some other form of systematic presentation. Structural formulae are given for all substances and the formulae for the carbohydrates are in accordance with Haworth's findings. Prominence is given to color reactions for the ready recognition of specific substances and groups of substances and one section is devoted to the use of such methods in microscopy. In general, the text is meant to summarize the data of organic chemistry rather than to expound it for beginners. The bibliographies that follow each chapter are adequate and there is an excellent index.

INDUSTRIAL POSSIBILITIES OF SOME RESEARCH WORK DONE IN INDIA.

By Gilbert J. Fowler. Society of Biological Chemists, Indian Institute of Science, Hebbal P.O., Bangalore. Re. 1. $8\frac{1}{2}$ x $5\frac{1}{2}$; 42; 1934 (paper).

A brief description of the local commercial and industrial exploitation of the results of bio-chemical researches conducted at different Indian institutes and universities. The subject matter is classified in (1) researches resulting in permanent factories, (2) researches resulting in factory operations still in the initial stage, (3) researches resulting in factories now discontinued for various reasons, (4) researches not fully exploited, (5) researches which await commercial consideration. It appears that by stimulating scientific activity there are great possibilities for further economic development in India.

LABORATORY MANUAL OF PHYSIOLOGICAL CHEMISTRY. *Third Edition.*

By Meyer Bodansky and Marion Fay. John Wiley and Sons, New York. $2.00 net. 9 x 6; vii + 274; 1935.

In volume 4, page 148 of the QUARTERLY

REVIEW OF BIOLOGY, is a review of the first edition of this manual. The present edition shows considerable change. The chapter on colloids has been omitted since the authors believe that adequate treatment of the subject cannot be included in a manual of the size of the present one. The order of some of the chapters and experiments has been changed and at many points additional material has been added. The table of atomic weights has been brought up to date.

DIE RÖNTGENSPEKTROGRAPHIE ALS UNTERSUCHUNGSMETHODE *bei hochmolekularen Substanzen, bei Kolloiden und bei tierischen und pflanzlichen Geweben. Handbuch der biologischen Arbeitsmethoden. Lieferung 436.*

By J. R. Katz. Urban und Schwarzenberg, Berlin. 20 marks. 10 x 7; 316; 1934 (paper).

This monograph is based on the lectures delivered to students of chemistry by the author every second year at the University of Amsterdam. The book is chiefly an elaborate description of technique, and is therefore, as the author admits, of little value unless used in conjunction with laboratory work. The work is very thoroughly done and contains descriptions of the best methods of X-ray for every kind of animal and plant tissue.

RECHERCHES EXPÉRIMENTALES SUR QUELQUES ESTERS DE LA CHOLINE.

By Maurice Villaret, L. Justin-Besançon and René Cachera. Masson et Cie, Paris. 38 francs. 10 x 6½; 254; 1934 (paper).

Here are offered the results of twenty years' experimental work on laboratory animals and man on the effects of different doses of some of the cholines, notably acetylcholine and methylacetylcholine, on the cardio-vascular and respiratory systems and gastric secretions. Charts, a three page list of works by the authors and co-workers, and an index are provided.

MIKROCHEMIE DES BLUTES. *Monographien aus dem Gesamtgebiete der Mikrochemie.*

By Friedrich Rappaport. Emil Haim und Co., Vienna. 15 marks (paper); 16.80 marks (cloth). 9⅜ x 6¼; xi + 206; 1935.

A hand-book of blood analysis techniques given under the headings of principle of method, reagents to be used, the procedure, the method of calculating the result, an example worked out, and then some sort of interpretive remarks showing clinical conditions where the analysis at hand is to be used and what order of numerical values is to be expected.

SEX

WOMEN ON THEIR OWN.

By Olga Knopf. Edited by Alan Porter. Little, Brown and Co., Boston. $2.75. 8⅝ x 5¾; 306; 1935.

Dr. Knopf was born and educated in Vienna where she did a large part of her medical work until she came to New York in 1931. Although she served as a surgeon during the war and later practiced as a specialist in gynecology her main interest lay in medical psychology, and for the last ten years her work has been in this field. Her book is written for the average American woman. She does not always grasp the American viewpoint but she has produced a sane, sensible book which probably could be applied generally to women in any civilized country. She discusses woman in relation to her men friends, her women friends, and her fellow workers, choice of work, career, and marriage, women of the new era and the question as to whether marriage can solve a personality problem. There is some analysis of neurotic and psychopathic types but in the main the book is rather a guide to the normal woman in the solution of such ordinary difficulties as beset her.

TEST TUBE BABIES. *A History of the Artificial Impregnation of Human Beings, Including a Detailed Account of its Technique, Together with Personal Experiences, Clinical Cases, a Review of its Literature, and the Medical and Legal Aspects Involved.*

By Hermann Rohleder. The Panurge Press, New York. $3.50. 9¼ x 6¼; 248; 1934.

This volume gives a "history of the arti-

ficial impregnation of human beings, a detailed account of its technique, together with personal experience, clinical cases, a review of its literature, and the medical and legal aspects involved." In an appendix is reprinted a letter addressed to the Royal Society in 1750—*Lucina sine Concubitu*. The volume is neither documented nor indexed. That the author is unfamiliar with recent work on the most favorable period during the monthly cycle for conception is indicated by his statement that: "It is a well-known fact that fertilization is easier during menstruation than otherwise." Possibly his record of five successful cases out of nineteen cases would have been considerably bettered had he been aware of modern investigations along this line.

FIT OR UNFIT FOR MARRIAGE.

By Th. H. Van de Velde. Chapman and Hall, London. 10s. 6d. net. $8\frac{1}{2}$ x $5\frac{1}{2}$; xii + 362; 1934.

The object of this book is

> to explain to young people of both sexes, especially before they decide to become engaged, the importance of making up their minds regarding their own fitness as well as the fitness of their partner for the obligation of marriage. It seeks to enlighten parents and guardians as to the direction in which they should use their influence, and to give to those already married who find themselves bound to an unsuitable partner such insight into the causes of their misfortune as will enable them to obtain help in dealing with their difficulties.

FASES BIOLOGICAS DE LA MUJER (Cartas a Paloma). *Pubertad, Noviazgo, Boda, Embarazo, Parto, Puerperio, Crianza, Aborto, Esterilidad, Complejo de Maternalidad, Procreación Consciente, Edad Critica, Menopausia.*

By Francisco Haro. Javier Morata, Madrid. 5 pesetas. $7\frac{1}{2}$ x 5; 230; 1934 (paper).

In a series of letters to an imaginary young lady, Paloma, supposedly written at different periods in her life, the author gives excellent medical advice. The first letter follows the girl's menarche and in it is given the explanation of the phenomenon and the care to be taken. The other letters regard the girl's engagement, marriage, pregnancy, delivery, abortion, and desire for family limitation. A last letter treats of menopause and its consequences. The literary form used appears to be well adapted to the subject, probably because the author is at all times a friendly physician and never a preacher.

THE TECHNIQUE OF CONTRACEPTION. *An Outline. Second Edition.*

By Eric M. Matsner. Published for the American Birth Control League, by The Williams & Wilkins Co., Baltimore. 50 cents. $8\frac{7}{8}$ x $5\frac{7}{8}$; 38; 1934 (paper).

The first edition of this book was reviewed in Volume 8, page 378. Dr. Matsner divides the methods of contraception which he describes into: those found to be most practical and therefore most acceptable to prescribe; those found to be impractical for general use, uncertain and questionable; those needing further experimental and developmental research before being prescribed for general use. However, he admits that the ideal contraceptive has not yet been found. There is a bibliography of one page.

AMERICAN ENCYCLOPEDIA OF SEX.

By Adolph F. Niemoeller. The Panurge Press, New York. $5.00. $9\frac{1}{4}$ x $6\frac{1}{8}$; 277; 1935.

With the aid of this dictionary even the most delicately nurtured person should be able to understand pseudo-scientific literature on sex, journalistic pornography, the language of taxicab drivers, and the chalked inscriptions that appear on sidewalks and fences in the spring of the year. Only the coarser expressions in use in rural regions are omitted.

THE SAFE PERIOD *or the Natural Method of Birth Control.*

By William J. Robinson. Eugenics Publishing Co., New York. 10 cents. $7\frac{3}{8}$ x $5\frac{1}{8}$; 16; 1935 (paper).

In a sprightly style the author gives a

popular explanation of the Ogino-Knaus theory of the female "safe-period." He justly cautions that too much reliance cannot be placed on the "safe-period" and remarks in characteristic manner: "Trust in the Ogino-Knaus theory and have a prevenceptive jelly handy."

BIOMETRY

STATISTICAL CONFLUENCE ANALYSIS BY MEANS OF COMPLETE REGRESSION SYSTEMS. *By Ragnar Frisch. Universitetets Økonomiske Institutt, Oslo.* 9¼ x 6; 192; 1934.

In partial regression analysis there is danger of obtaining meaningless results whenever one includes in the same regression equation a set of variates containing two or more subsets which are already highly correlated. For instance, suppose that we are considering three variates between which there exist two linear equations. When observations are represented in three dimensional space all the points will lie on a straight line and, while the zero-order regression of any one of the variates on any other is perfectly determinate, the partial regression of one variate on any other is indeterminate. If the variates are subject to random errors the regression coefficients will no longer be of the indeterminate form 0/0, but will be the quotient of one random error by another. These apparently determinate regressions will therefore be meaningless. The author believes that as a result of neglect of this point "a substantial part of the regression and correlation analyses which have been made on economic data in recent years is nonsense." In this interesting book he develops methods intended to warn the statistician of this pitfall. These methods are based in part on the reduction in variation of the observed points around the regression plane as new variates are added and in part on the criterion that a regression coefficient between two given variates should change but little when based on minimization of sum square residuals in different directions. In an artificially constructed example the new technique yields conclusions agreeing with what is known *a priori* about the manner of construction of the variates. In another example it is applied to measuring money flexibility from a six-variate analysis of annual consumption statistics from 1919 to 1931. Perhaps we are old fashioned but to us a six-variate analysis based on thirteen observations seems rather like overfitting.

COMPARABILITY OF MATERNAL MORTALITY RATES IN THE UNITED STATES AND CERTAIN FOREIGN COUNTRIES. *A Study of the Effects of Variations in Assignment Procedures, Definitions of Live Births, and Completeness of Birth Registration. U. S. Department of Labor, Children's Bureau, Publication No. 229. By Elizabeth C. Tandy. U. S. Government Printing Office, Washington.* 5 cents. 9 x 5¾; v + 24; 1935 (paper).

The high maternal mortality rates for the United States as compared with those for other countries have been often attributed to the difference in assignment procedures of cause of death. In order to obtain data on the extent of this difference 477 selected United States death certificates, on which pregnancy or childbirth were mentioned, were sent to the Vital Statistics Bureaus of 16 foreign countries with the request to classify the cause of death as puerperal or non-puerperal. Statistical analysis of the results leads the author to conclude "that differences in methods of assignment are insufficient to explain the high mortality rate of the United States as compared to foreign countries." In addition, the author finds that differences in definition of live births and the incompleteness of birth registration here are not factors of great importance "in connection with comparability."

FOREST MENSURATION. *By Donald Bruce and Francis X. Schumacher. McGraw-Hill Book Co., New York.* $3.50. 9 x 6; xiv + 360; 1935.

A textbook of mathematical technique in the collection and elaboration of quantitative data in forestry. The first part, on direct measurements, describes the instruments and methods of measuring diameter,

height, volume, and age of trees. It is introduced by a good though brief discussion on measurement in general. In the second and third parts there is an outline of elementary statistical methods, calculations of constants, measures of dispersion, the fitting of simple curves, together with numerous applications to problems in forestry. This volume lacks a comprehensive bibliography, but there is an appendix with some useful tables.

TREND ANALYSIS OF STATISTICS. *Theory and Technique.*

By Max Sasuly. Brookings Institution, Washington. $5.00. 9½ x 6¼; xiii + 421; 1934.

This is a treatise on the least square fitting of polynomials and on related topics, such as interpolation and fitting by moving polynomial arcs and moving averages. Extensive use is made of orthogonal polynomials and of factorial moments instead of the usual power moments. Tables of coefficients useful in fitting, bibliographic footnotes and indexes are provided.

PSYCHOLOGY AND BEHAVIOR

COMPARATIVE PSYCHOLOGY MONOGRAPHS, *Vol. 11, No. 2, Serial No. 52. Studies of Cerebral Function in Learning. XI. The Behavior of the Rat in Latch Box Situations. The Mechanism of Vision. XII. Nervous Structures Concerned in the Acquisition and Retention of Habits Based on Reactions to Light.*

By K. S. Lashley. The Johns Hopkins Press, Baltimore. $1.25. 10 x 6⅞; 79; 1935 (paper).

Since the days of Gall and Spurzheim the problem of localization of function in the brain has puzzled psychologists. On the one hand it has been concluded that there is a high degree of specialization of certain functions; on the other hand various investigators, especially Franz and Lashley, have found evidence that the cortex functions as a whole. In the two parts of this interesting monograph Lashley deals with the retention and relearning of latch box habits and of visual discriminations by rats after experimental extirpation of parts of the cortex. With regard to the latch box habits he concludes "that the mechanism of association, as such, is not disturbed by cerebral lesions and that retardation from cerebral lesions is due rather to disturbance of such functions as are implied by the terms attention, insight and initiative."

As to visual discrimination

> So long as any small part of the geniculo-striate system remained intact perfect retention of the habit was possible. . . . With complete destruction of both striate areas and complete degeneration of the lateral geniculate nuclei, the animals required as much practice for relearning as for initial learning before the operation. The postoperative loss or the habit thus follows an all-or-nothing principle, and occurs only after complete destruction of the striate areas. Computation of correlations between extent of cerebral lesion and postoperative training records gives coefficients of about 0.60, due to the inclusion of cases with and without complete destruction of the striate areas. My earlier conclusion that the loss of the habit is proportional to the amount of tissue destroyed, irrespective of locus within the visual areas, was therefore incorrect.

STUDIES IN INFANT BEHAVIOR I. *University of Iowa Studies. Studies in Child Welfare. Volume IX, No. 4, New Series No. 281.*

By Orvis C. Irwin, LaBerta A. Weiss, and Esther M. Stubbs. University of Iowa, Iowa City. $1.35 (paper); $1.70 (cloth). 9¼ x 6; 175; 1934.

BEHAVIOR OF THE PRESCHOOL CHILD. *University of Iowa Studies. Studies in Child Welfare. Volume IX, No. 3, New Series No. 275.*

By Lois M. Jack, Elizabeth M. Manwell, Ida G. Mengert, Esther Van C. Berne, Helen G. Kelly, LaBerta A. Weiss, Agnes F. Ricketts. University of Iowa, Iowa City. $1.35 (paper); $1.70 (cloth). 9¼ x 6; 171; 1934.

The first of these studies comprises five wholly separate and complete investigations on the new-born infant. Part I is concerned with differential variations in the amount of activity of new-born infants under continuous light and sound stimulation; Part II deals with the effect of the factors of duration, intensity and pitch of sound stimuli on the responses of new-born infants; Part III is a study of differential

variations in the activity and crying of the new-born infant under different intensities of light; Part IV, The effect of clothing on the general and vocal activity of the new-born infant, and Part V, The effect of darkness on the activity of new-born infants. The experimental findings in each of the five studies were treated biometrically, and will provide useful data for future research on infant behavior.

Studies in the behavior of the preschool child were made on 2, 3 and 4 year old children. The first of the studies deals with an experimental study of ascendant behavior in preschool children. Ascendancy is defined as follows: "An ascendant individual is one who acts in accordance with his own desires and places himself in a position of advancement." Ascendancy was correlated with such characteristics as social responsiveness, expansive behavior, competitive attitudes, etc. Part II concerns a study of the development of two and three year old children with respect to play activities. Part III is an extremely interesting section on the adequacy of samples of behavior obtained during short observation periods; Part IV is an experimental investigation of certain factors involved in the preschool child's compliance with commands, and Part V is a study of the behavior of young children in anger.

PSYCHOLOGY AND HEALTH.

By H. Banister. The Macmillan Co., New York. $2.50. $7\frac{3}{4}$ x $5\frac{1}{4}$; viii + 256; 1935.

A highly useful book for doctors, parents, teachers and social workers. The author is a lecturer in experimental psychology in the University of Cambridge. He sets forth in these pages the theories of Janet, Freud, Jung and Adler but follows no one school to the exclusion of the others; he discusses the problem child and infantile sexuality: the importance for the doctor of a knowledge of psychology and the troubles which he is called upon to face not only in the mentally diseased but in the healthy minded patient as well; treatment by suggestion, and by analysis. In the final chapter there is discussed at length the author's views on what he terms the "sentiment formation tendency" and he concludes with the statement that "I strongly hold that everyone would be the better if he understood something of the growth of sentiments, of the formation of character, and of the dangers and ills that may accrue if, from any cause, the proper development of sentiments is impeded. The dissemination of this knowledge is, I think, one of the most important duties of the already overburdened general practitioner." The volume contains a useful bibliography and an index.

THE FUNCTIONS OF THE VISUAL AREAS OF THE CEREBRAL CORTEX OF THE RAT IN THE LEARNING AND RETENTION OF THE MAZE. I. *Comparative Psychology Monographs, Vol. 10, No. 4, Serial No. 50.*

By Yü-Chüan Tsang. The Johns Hopkins Press, Baltimore. $1.00. 10 x 7; 56; 1934 (paper).

The problem as stated by the author in the opening paragraph is: "Is the function of the sensory areas of the cerebral cortex strictly sensory or imaginal, or do the areas have some additional function which is not directly related to their sensory processes but is a less specific contribution to the general efficiency of the performance."

Maze performance tests were made on 96 female rats, divided into five groups: (1) Normal controls; (2) Peripherally 'blinded', both eyes enucleated; (3) Cortically 'blinded', visual cortex destroyed, eyes intact; (4) Both peripherally and cortically blinded, both eyes and visual cortex removed; (5) A control group, partially cortically blinded.

The essential point to come out of the experiment was that destruction of the visual cortex in part or in whole is significantly more detrimental to maze performance than just peripheral blinding, that is, removal of the eyes. The author believes that the inability of the cortically operated animals to adjust themselves to the maze is due to "the mutilation of the cerebral integrative function, that is to general dementia."

HUMAN PERSONALITY AND THE ENVIRONMENT.

By Charles M. Campbell. The Macmillan Co., New York. $3.00. $8\frac{1}{2}$ x $5\frac{5}{8}$; xi + 252 + 6 plates; 1934.

In this book, originally given as a series of Lowell lectures, a wise and understanding psychiatrist attempts "to give a more vivid and precise meaning to the word personality, and to stimulate the interest of [the reader] in the driving forces of the individual life." He deals in turn with the relation of the personality to the physico-chemical environment and to the physiological mechanisms of the organism, its development from the ovum to the adult, its dynamic systems and their integration, some of the tasks which confront it, such as the maintenance of its integrity and of equilibrium between conflicting internal tendencies, and finally "some of the ways in which the individual attempts to do justice to the needs of his own complex nature and to play his rôle in the endless drama of the universe." There are numerous bibliographic footnotes and an index.

A TEXTBOOK OF EXPERIMENTAL AND THEORETICAL PSYCHOLOGY.

By Ernest B. Skaggs. Christopher Publishing Co., Boston. $4.00. $9\frac{1}{4}$ x 6; 426; 1935.

A very fair, unbiased text-book on psychology written from the point of view "that all explanation of an immediate kind in psychology must be in terms of the structure and functioning of the nervous system."

One characteristic of the book which should be very helpful to the student is the author's admirable habit of stating all sides of a controversial subject, then giving his own position and explaining why he holds it.

Our chief complaint with the book is in regard to the cuts. The figures such as those of the ear and brain structure are too small and too dark to show the requisite detail.

PSYCHO-ANALYSIS FOR TEACHERS AND PARENTS. *Introductory Lectures.*

By Anna Freud. Translated by Barbara Low. Emerson Books, New York. $1.75. $7\frac{1}{4}$ x $4\frac{7}{8}$; 117; 1935.

In this day and age when Oedipus complexes provide dinner table conversation this little book seems unnecessarily simple and elementary. But perhaps Sigmund Freud's daughter—the author—knows what an audience of teachers needs and wants in such matters. The unconscious, repression, reaction-formation, sublimation, complexes, the libido, the theory of infantile sexuality—these are all explained very simply and untechnically. There is very little of practical advice as to how to avoid the unpleasant results of misguided repressions, however.

DIE TIERPSYCHOLOGISCHE FORSCHUNG. *Ihre Ziele und Wege. Bios Band II.*

By J. A. Bierens de Haan. Johann Ambrosius Barth, Leipzig. 6.60 marks. $9\frac{1}{4}$ x $6\frac{1}{4}$; xi + 96; 1935 (paper).

The author has done an excellent piece of work in presenting, in somewhat less than 100 pages, a readable, comprehensive survey of the experimental work on animal psychology and behavior—methods and their development, aims, and results. Several times he emphasizes the need of caution in the interpretation of results, especially in two special sections on reflex action and performance, and the "consciousness" of animals. An eight-page bibliography is provided but there is no index.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

COSMOGONIES OF OUR FATHERS. *Some Theories of the Seventeenth and the Eighteenth Centuries.*

By Katharine B. Collier. Columbia University Press, New York. $5.00. $8\frac{3}{4}$ x $5\frac{7}{8}$; 500; 1934.

As the author of this interesting study of a curious phase in the history of science points out, when new scientific discoveries conflict with old cosmological doctrines, sanctioned by religious tradition, four types of reaction are possible. "The first type is a vigorous rejection of all new

thought that does not square with the old; the second, a discarding of all the old because of its apparent disagreement with the new; the third, a peculiar arrangement of the mind in thought-tight compartments to prevent any influence from one set of doctrines upon another; and the fourth an attempt to harmonize the new with the old thought."

This book is a history of reconciliatory gymnastics during the seventeenth and eighteenth centuries. In Roman Catholic countries the burning of Bruno and the condemnation of Galileo made authors wary of attempting to show that the newer doctrines might be harmonized with the Biblical account. In Protestant countries, on the other hand, and especially in England, the reconcilers flourished. Fludd, Burnet, Warren, Keill, Ray, Whiston, Woodward, Grew, Dickinson, Witty, Derham, Hutchinson, Swinden and Pike, among others, produced works in which the Biblical narrative and the science of the day are stretched and squeezed in various ways to fit each other. In the middle of the eighteenth century Buffon suggested that the days of creation were really epochs, each of several thousand years, a device that has retained its popularity among reconcilers to the present time. By the end of the eighteenth century, however, general opinion had come to agree with Baronius that the Bible was written to teach mankind how to go to heaven and not how the heavens go. The astronomers were left free to develop their subject in their own way. However, the biologists had later to fight for the like freedom.

The book contains a bibliography of 24 pages and an index.

A History of Magic and Experimental Science. *Volumes III and IV. Fourteenth and Fifteenth Centuries.*

By Lynn Thorndike. Columbia University Press, New York. $10.00 per set. 8⅝ x 5½; Vol. 1, xxvi + 827; Vol. 2, xviii + 767; 1934.

In these two massive and carefully documented volumes Professor Thorndike carries to the beginning of modern times the history of that strange mixture of magic, rationalism, and observation from which modern science developed. On the whole the occult predominates in the record of these, as of preceding centuries. Yet the quantitative interests of Richard Suiseth, called Calculator, Henry of Hesse, Oresme, Blasius of Parma and Nicholas of Cusa, the astronomical clocks of James and John de Dondis, the anthropological observations of Michael Savonarola, and the recognition of erosion and the gradualness of geological change by John de Fundis, are all adumbrations of the new spirit which was to accomplish such notable things in the seventeenth and later centuries. Of particular interest to a biometrician is Oresme's discussion of "latitude," as in his statement that "between maximum and minimum . . . there is greater latitude in one species than in another," greater in men, for example, than in hares. This seems to foreshadow the modern biometric interest in relative variability.

John de Dondis in his *De Fontibus* speaks of having been in medical attendance on "Galeacii Vicecomitis Mediolani et comitis virtutum filius praeclarae indolis." Thorndike renders this as "the son of Galeazzo Visconti, count of Vertus." But is "virtutum" the name of a place? Is not the meaning of the passage somewhat as follows: the son of Galeazzo Visconti, of Milano, count of illustrious spirit and valor?

Le Nouvel Esprit Scientifique.

By Gaston Bachelard. Félix Alcan, Paris. 10 francs. 7⅜ x 4¾; 180; 1934 (paper).

According to Professor Bachelard the newer advances of science have been made, not by the refinement of older theories through a process of successive approximation, but by a critical examination of the basal postulates of the older theories. Thus Lobatchewsky, exploring the results of a denial of the postulate of parallels, was led to the development of a non-Euclidian geometry, which includes Euclidian geometry as a special case. Thus Einstein, starting from a critical examination of the supposedly primitive idea of simultaneity, arrived at a non-Newtonian mechanics, which again includes New-

tonian mechanics as a special case. Wave mechanics and the theory of quanta are further examples of the same process, which Bachelard regards as the development of a non-Cartesian epistemology. In place of the criteria of simplicity and clarity by which Descartes tested the ideas which were to serve as foundation to the edifice of the sciences Bachelard would substitute the criterion of completeness. He is moreover well aware that as the structure grows it may be necessary to take out the old corner stone and replace it with a new one. This stimulating book recalls an idea that Merz developed a number of years ago in his *History of European Thought*, that analysis and subsequent synthesis carry one only a certain distance in his quest for understanding, that they need to be supplemented by a synoptic method which regards phenomena in their *relations* with other phenomena.

GRAVITATION, SPACE-TIME AND MATTER. *A Study of the Relation of Gravitation to the Flow of Time; the Atomic Organization of Space-Time; the 126 Isotopoids of Hydrogen; and the Photonic Nature of the Atoms.*

By Albert P. Mathews. Albert P. Mathews, University of Cincinnati. 9¼ x 6⅛; 103; 1934 (paper).

The author has attempted here to build upon the more recent discoveries in theoretical physics a new philosophical system. The results of his discussion can be summarized as follows:

Light = Matter = Electricity = Ether = Space-time = Life.

Everything is constituted of Life, another name for reality. For it is Life which appears in these various external guises of activity and passivity; of becoming and being; and which appears also in the internal guise of mind.

There are obviously two kinds of space-time; two kinds of Life: Material and immaterial; created and uncreated; mortal and immortal.

The whole of space-time, both material and immaterial, created and uncreated, in its objective aspect of activity, i.e., its aspect of discontinuity, has an atomic structure. It presents itself to us as an immense swarm of Living Units or organisms. These are the di-poles; the created and uncreated hydrogen atoms; the created and uncreated photons. For if the material be considered to be granular, as it must be considered in its activity aspects, then the immaterial or uncreated must also be so considered. If we are living individuals, the immaterial must also be constituted of immaterial living individuals.

LIONS STARVE IN NAPLES.

By Johan Fabricius. Translated from the German by Phyllis and Trevor Blewitt. Little, Brown and Co., Boston. $2.00. 7½ x 5; 311; 1935.

This tale of the spiritual and material development of that talented young Neapolitan lawyer Ramboldo Fittipaldi, as Storm's Circus got deeper and deeper into difficulties because of the depression and a terribly cold winter, is delightful. No biologist could possibly resist its charm —nor, for that matter, anybody else so far as we can see. Its relation to biology is indirect; perhaps a pedant might even say remote. But this is really not so. To the human biologist it is a superb document. It gives such a picture of Neapolitan character as has never been put on paper before. Our advice to all and sundry is to buy, beg, borrow or steal it at once, and settle down to some hours of unadulterated enjoyment.

DICTIONARY OF FOREIGN TERMS *Found in English and American Writings of Yesterday and Today.*

By C. O. Sylvester Mawson. Thomas Y. Crowell Co., New York. $2.00. 7⅜ x 5; x + 389; 1934.

This extremely useful dictionary contains a variety of foreign expressions which one finds more or less frequently in literature, periodicals and the daily press. Included in the contents are (1) foreign words and phrases from more than fifty languages, (2) proverbs, (3) mottoes, (4) quotations, (5) French and Spanish Americanisms, (6) Orientalisms, (7) naval and military terms, (8) menu terms, (9) translations or definitions of all foreign terms, (10) plurals, (11) feminines of foreign nouns and adjectives, and (12) foreign abbreviations.

METAMORPHOSES.

Drawings left by Dr. Marianne van Herwerden. Joh. Enschedé en Zonen, Haarlem. 2.25 guilders. 8¼ x 5¼; 76; 1934.

While we had known and admired for many years the late Dr. Marianne van Herwerden, we were not aware of her talents as an imaginative artist and humorist until this charming little posthumous volume came to hand. The introduction explains its provenance.

Fig. 262. Querdurchschnitt einer Schneckenwindung: vom Meerschweinchen.
TOLDT, C. *Lehrbuch der Gewebelehre* (1885).

Dr. Marianne van Herwerden, a well-known Cytologist and Geneticist has left a number of drawings, some of which are published in this booklet.

It was only in the later years of her life that she took up this playing with lines and forms. As a rule she made these drawings late in the evening after a day of strenuous brain work. Then she gave her sense of humour and exquisite wit free scope and then the figures out of scientific works reappeared in a new shape. In making these drawings no publication was aimed at. Even by careful research it has not been possible to identify all of the drawings; so some of them have been taken up without any corresponding scientific figure.

Limitations of space and technique prevent the presentation here of adequate examples of the delightfully fantastic bits of wit that fill the book. Many

of the drawings are in color. However, we do like the one here reproduced that falls within our limitations.

All biologists owe a debt of gratitude to Dr. Marie Löhnis for collecting the drawings and seeing through the press this charming memorial of a distinguished cytologist and geneticist.